

WIN \$250,000 CASH! ENTER TO WIN PAGE 8

10 BEST CARS & TRUCKS OF THE YEAR

2011 CHEVY VOLT



Popular Mechanics

SCIENCE TECHNOLOGY AUTOMOTIVE

POPULARMECHANICS.COM
DECEMBER 2010

CHINA'S SECRET WAR PLAN

THEIR NEW TECH & TACTICS TARGET OUR AIRCRAFT CARRIERS

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HYPERSONIC
MISSILES
HOW THE U.S.
CAN STILL
PREVAIL

PM HELPS
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CARVE UP
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DIY

HYBRIDS HOW-TO
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2010

Dec.

PM FEATURES /// VOL. 187 NO. 12

MythBusters Adam Savage and Jamie Hyneman inspect the body of a Porsche 928 at M5 Industries in San Francisco, July 2010.

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Fast Backwards Could the Porsche 928 be more aerodynamic—and faster—with a 180-degree design flip? MythBusters Jamie Hyneman and Adam Savage enlist our senior auto editor to spearhead the radical, intricate build and take the inverted beast for a test drive. **BY MIKE ALLEN**

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China has been devising strategies and amassing weapons for a possible future invasion of Taiwan, including a way to block U.S. intervention. PM investigates these clandestine battle plans—and the new tech and tactics that would give America the upper hand.

BY ERIK SOFGE

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BY ERIN MCCARTHY

94 Home Ice

Hoping to make the most of Michigan's forbidding winter, a father of three enlists his neighbors to build a backyard rink. The process turns out to be more challenging than skating on the finished product.

BY LARRY WEBSTER

100 The Race to Save the Bats

A mysterious epidemic has wiped out nearly 2 million North American bats in just four years. Deep in a Pennsylvania iron-ore mine, scientists test an experimental compound that could be this creature's last hope for survival.

BY LOGAN WARD

ON THE COVER

For PM's cover story about a hypothetical invasion of Taiwan, photographer Dan Saelinger and stylist Laurie Raab created this scenario dramatizing the existence of documents that detail Chinese strategies to thwart U.S. power in the Pacific.

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'Tis the season to ask for these 25 gadgets, tools and toys, from the Porter-Cable 12-Volt Max Clamp Saw to Cuisinart's see-through EasyPop popcorn maker. **Plus:** Tips and tricks to get the most out of your holiday bounty.



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× DECEMBER

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popularmechanics.com/home/reviews



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- Pay down your mortgage (or buy a vacation home).
- Send a deserving youngster (perhaps your own) to a top engineering school.
- Fund the construction of three houses through Habitat for Humanity.
- Sign up for flying lessons—and pick yourself up a single-engine Cessna to go with them.

To enter, go to:
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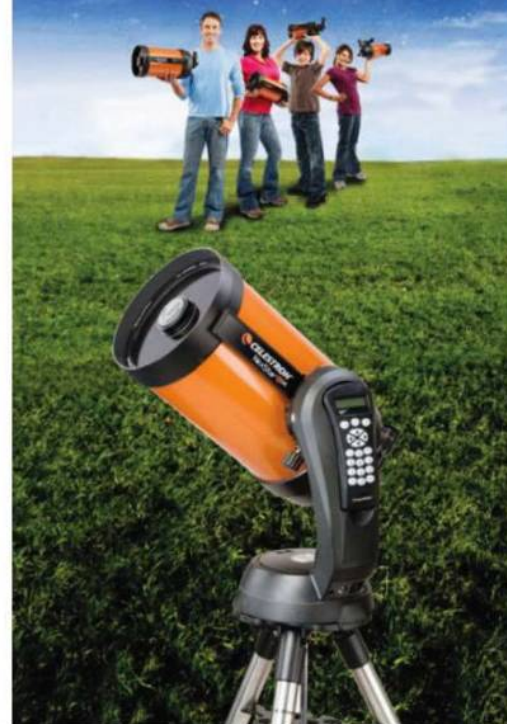
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PM LETTERS

Lessons Learned

I just wanted to commend you for a great article on the Deepwater Horizon spill ("How the Blowout Happened") in the October issue. Well-written, very interesting, very informative, very shocking—and very scary. It should be required reading for every member of Congress.

JERRY CABAK
SANTA CRUZ, CA

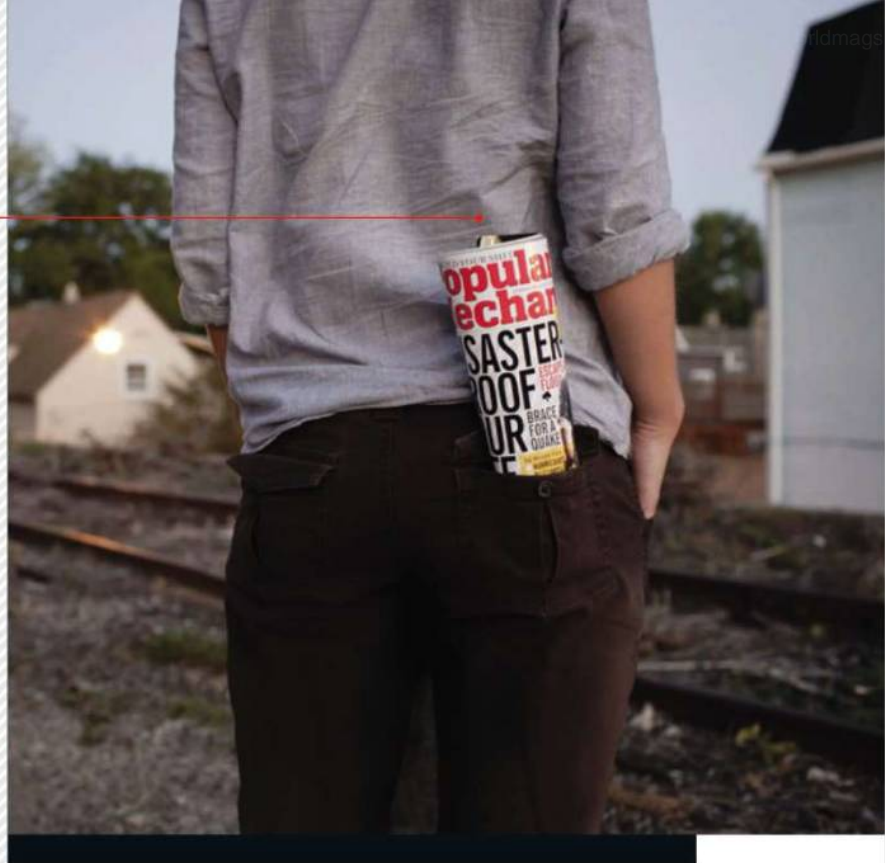
I've been a safety professional for over 35 years, and I think

Oct.

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Readers responded to our stories about disaster prep and the Deepwater Horizon oil spill.



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every industrial-process manager in the country should read your Editor's Note and article on the BP well blowout. I have not seen such a comprehensive article on the event. As a resident of Alabama, I believe that our beautiful coast is a national treasure and that people need to be held accountable for such accidents. As DuPont states, over 96 percent of accidents are the result of human negligence. Thank you for your thoughtful, informative and understandable magazine.

JOEL PRUDE
FLORENCE, AL

I had to read "How the Blowout Happened" twice. I found it nearly impossible to grasp the gross negligence of British Petroleum and the unfathomable depths of

arrogance and greed that made this event all but inevitable. I never thought Halliburton would be the voice crying out for the need to put safety before profits. Can one imagine if all of us performed our duties with these priorities reversed? I am an operating-room nurse, so the idea of putting economic considerations first makes my skin crawl. I never expected to understand what actually happened to cause this explosion, but the schematics of your article made it extremely easy to comprehend every single part of the disaster.

GEORGIA DALY
ANNAPOLIS, MD

When It Strikes

I found "Disaster-Proof Your Life" to be a timely and informative article. But I disagree with the suggestion that when building up a three-day emergency supply of food, one should buy "dried beans . . . and dried fettuccine." Both of these items require precious drinking water to rehydrate and some kind of stove and fuel source to cook. Imagine being stuck in 10 miles of stalled traffic and only then realizing that your emergency food needs to be boiled. I have found that it's far better to load up on precooked food, such as canned pasta or stew, which can be eaten cold right out

of the can if need be. Just remember to bring the all-important can opener!

JOSEPH BENEDETTO
PENN HILLS, PA

Your article about preparing for crises was very interesting. However, the author neglected to mention the need for a water filter. The article explained the importance of stockpiling fresh water, but having a filter on hand as a backup is a smart solution for those who may be forced to flee. Further, the article noted the need for a flashlight, but neglected to note the benefits of a waterproof one.

BRIAN CHERRY
GOLDEN VALLEY, MN

what
do you
think?
→

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Tech Watch



A New Home Network

Your home's electrical wiring can double as an antenna network, according to researchers from the University of Washington and the Georgia Institute of Technology. Typically, walls block conventional wireless signals, so the sensors monitoring "smart" homes quickly drain their batteries sending out data. The researchers invented a device that can send signals to the wiring behind walls using 100 times less power, allowing sensors to run almost indefinitely. — ALEX HUTCHINSON

QUICK HITS

Second Life for an Old Oxymoron



→ Researchers in Britain have found new potential for powder-like "dry water." Though it's composed of 95 percent water,

silica coating each droplet prevents the substance from behaving like a liquid at room temperature. Discovered in 1968, dry water was largely forgotten after attempts by the cosmetics industry to use it fell flat. Now, scientists at the University of

Liverpool have found that dry water can absorb carbon dioxide, which bonds with water molecules to form hydrates—an ideal medium for storing the greenhouse gas.

Gem of a Shave

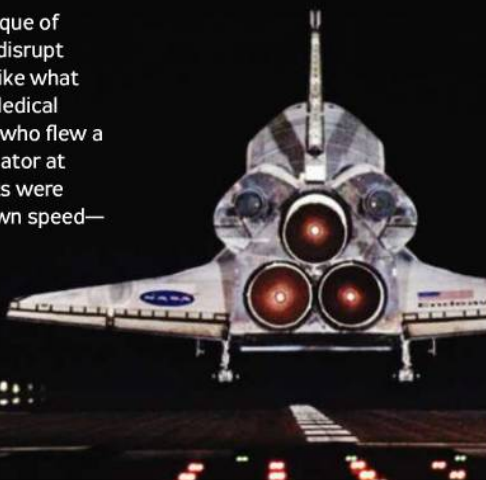


→ Diamonds may prove to be a man's best friend if the razor designed by German firm GFD lives up to its potential. The company bombards diamond-coated tungsten carbide blades with plasma to produce prototype razors that promise to keep an edge for years rather than weeks—perhaps long enough to make the gem-encrusted razor cost-effective for users. — A.H.

ANNALS OF VERTIGO

NASA's Disorientation Machine

Galvanic vestibular stimulation is a century-old technique of applying electric current to a nerve behind the ear to disrupt balance and vision. In fact, the effects are very much like what astronauts experience during and after spaceflight. Medical researchers recently completed tests on 12 subjects who flew a series of shuttle landings in the Vertical Motion Simulator at NASA's Ames Research Center. When the participants were subjected to GVS, they landed with a higher touchdown speed—similar to the experiences of shuttle pilots suffering from space-induced sensory disturbance. The researchers say adding GVS to space simulators will make them more realistic. — A.H.



DEBUNKED: HAND SANITIZER VERSUS THE FLU

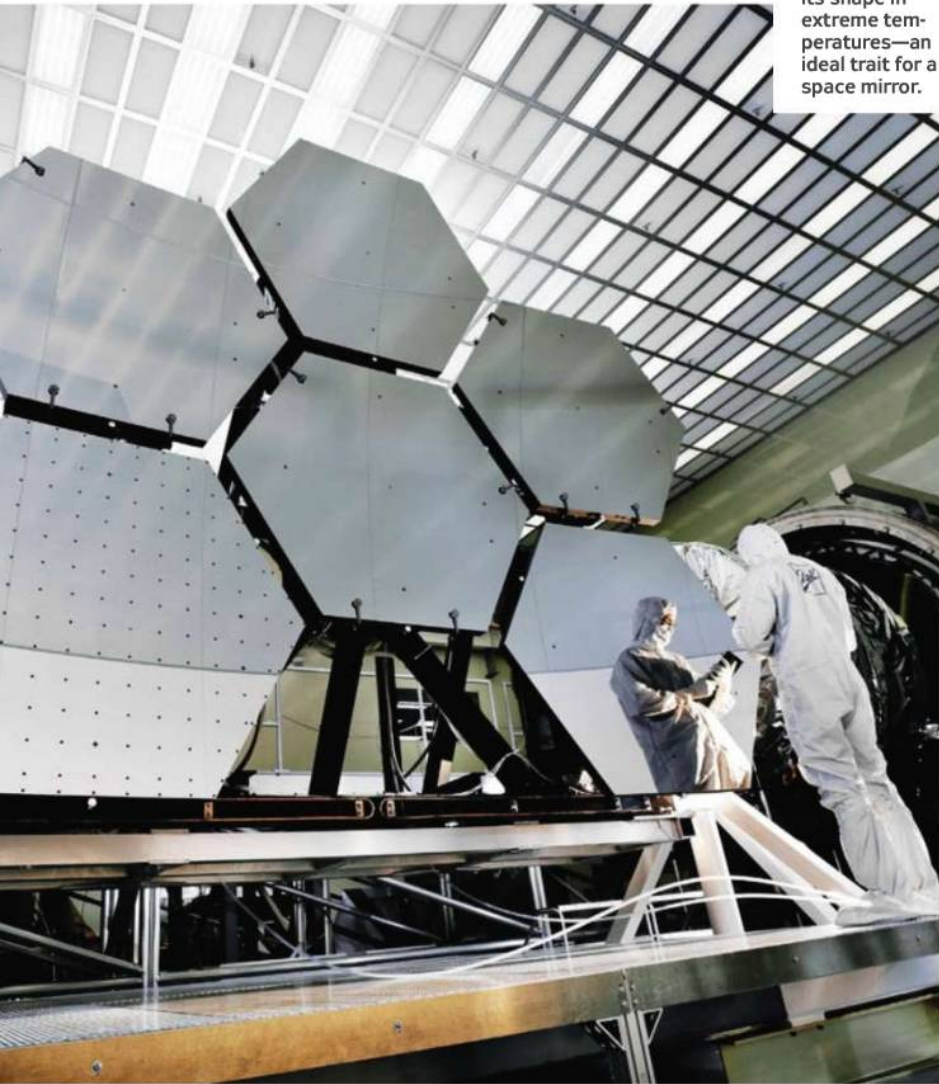
"An alcohol hand disinfectant with enhanced antiviral activity failed to significantly reduce the frequency of infection with either rhinovirus or influenza,"



write University of Virginia researchers in a recently released study on the effect of hand sanitizer during the H1N1 flu epidemic. "This study suggests that protection from infection with these viruses may require increased attention to aerosol transmission."

SPACE OPTICS

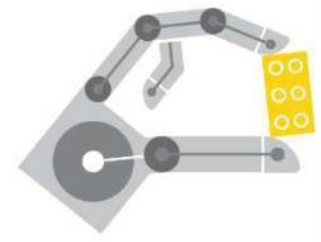
Beryllium holds its shape in extreme temperatures—an ideal trait for a space mirror.



Casting a Cold Eye

Predicting how a sensitive telescope will perform in the frigid environment of space can be a challenge. For example, in order to ensure the beryllium mirrors destined for the James Webb Space Telescope will function accurately, Northrop Grumman must cool them to minus 415 F—about 35 degrees cooler than operating temperature in orbit. The engineers then measure how the shape of every mirror changes and polish each to cancel out any warp, preventing deformations that could cloud the telescope's results.

A total of 18 mirrors will undergo this treatment before engineers at Marshall Space Flight Center in Huntsville, Ala., integrate them to form a single 21-foot reflective surface for the Webb, due to launch in 2014. The mirrors will direct faint infrared signals from distant planets, galaxies and stars, giving scientists an unparalleled perspective of the creation of the universe. — A.H.



NEW FORMS OF PERCEPTION

Dueling Recipes for Artificial Skin

→ We take our ultrasensitive, flexible skin (and its fingertip-to-brain response time) for granted—until we don't have it. Now, two efforts are leveraging electricity to bring artificial skin to prosthetic limbs: A Stanford lab has structured rubber to act as a capacitor; a grid of transistors detects pressure changes as slight as the weight of a fly. Scientists at Berkeley made "e-skin" from nanowire semiconductors applied to pressure-sensitive rubber. The next step for both teams? Make the skin inexpensive and pliable enough to cover a prosthetic hand. — OLIVIA KOSKI

STRAIGHT FROM THE SOURCE



"Four hundred names of known or suspected terrorists are added to the National Counterterrorism Center's watch list every day. The scale of the data coming into the NCTC is immense."

Michael Leiter,
DIRECTOR OF THE NCTC

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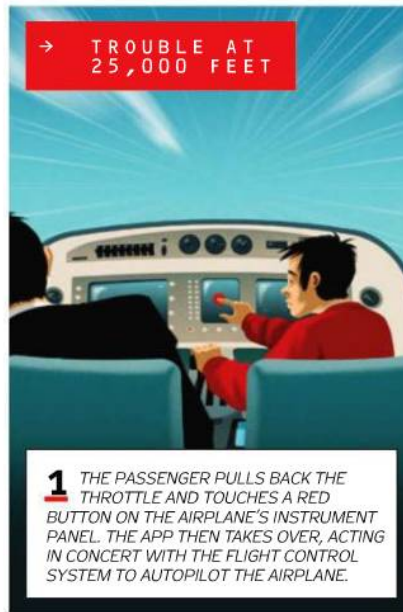
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AVIATION GADGETS

No pilot? There's an app for that.

It's every small-airplane passenger's worst nightmare: You're cruising over the clouds when the pilot suddenly clutches his chest and slumps forward, unconscious. Now what? Software entrepreneur and pilot Austin Meyer, creator of the X-Plane flight simulator, thinks he has the answer. He's written an iPad app, EFIS-App, that automatically finds a nearby airport and instructs the flight control computer to glide in for a safe landing. For now, the program only works with an iPad wirelessly linked to X-Plane. But next year, when Meyer finishes building his 380-mph Lancair Evolution kit plane, he will connect the app to the plane's flight control system and allow it to perform a landing. Assuming the program works, Meyer will make it available to owners of Evolutions and then, pending FAA approval, adapt it for use in other aircraft. — JEFF WISE



1 THE PASSENGER PULLS BACK THE THROTTLE AND TOUCHES A RED BUTTON ON THE AIRPLANE'S INSTRUMENT PANEL. THE APP THEN TAKES OVER, ACTING IN CONCERT WITH THE FLIGHT CONTROL SYSTEM TO AUTOPILOT THE AIRPLANE.



2 USING THE AIRPLANE'S ONBOARD SATELLITE NAVIGATION DATA, THE SOFTWARE FINDS AIRPORTS WITHIN GLIDING RANGE, ASSESSING DISTANCE, OBSTACLES, RUNWAY LENGTHS AND OTHER VARIABLES. IT ISSUES COMMANDS TO THE PLANE'SAILERONS, RUDDER AND ELEVATOR TO STEER TOWARD THE BEST OPTION.



3 THE PLANE DESCENDS THROUGH A SEQUENCE OF WAYPOINTS, THEN SETS UP FOR A STANDARD INSTRUMENT APPROACH. THE PASSENGER MANUALLY DEPLOYS THE LANDING GEAR BEFORE TOUCH-DOWN. EMERGENCY SERVICES, CONTACTED BY RADIO, ARE WAITING.

ROBO-EVOLUTION

A Cyborg's Sense of Smell



→ Scientists have devised ways for robots to see, feel and hear. But giving them a sense of smell has proved more difficult. Now, a team of Japanese

researchers has created a detector that uses genetically modified frog eggs to identify odors—and demonstrated it in a mannequin that shakes its head in the presence of

moth pheromones. The team, from the University of Tokyo, injects insect RNA into eggs from the African clawed frog; the RNA enables the eggs to express proteins that the insects use as smell receptors. In the case of the mannequin, genetic material from male silk moths produces receptors capable of bonding with the phero-

mones from females. When the frog egg is placed between two electrodes in the detector, the scientists can measure the electric current generated as this bond occurs. A single egg can be used to detect multiple odors by incorporating RNA from different insect species, or can even sense gases, such as carbon dioxide, by tapping into the

inherent abilities of meal-seeking mosquitoes. Other future robotic systems could potentially monitor food quality, the researchers say, or diagnose diabetes by detecting the ketone in patients' breath.

— JOE PAPPALARDO

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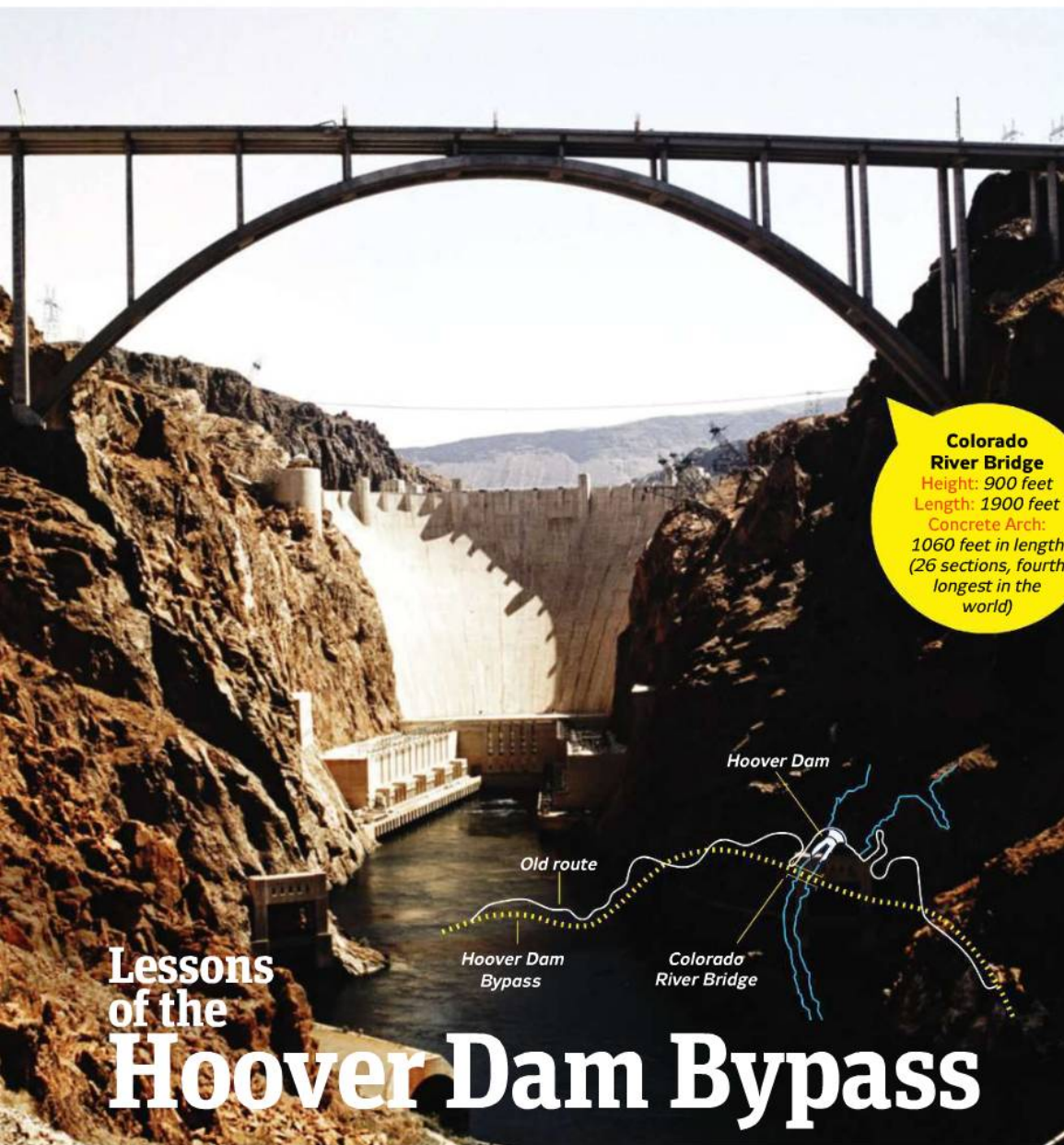
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MAJOR INFRASTRUCTURE



Lessons of the Hoover Dam Bypass

Nowadays, people expect mega-engineering projects to be over budget—and, often, underwhelming. But the newly opened Hoover Dam Bypass is an example of big-ticket civil engineering done right. The roadway—which spans the Black Canyon 1500 feet south of the dam—provides a more direct route between Arizona and Nevada, cutting travel time by as much as two-thirds. The concrete arch of the Colorado River Bridge—one of nine new bridges—seamlessly complements the iconic Hoover Dam, and its deck offers pedestrians a new vantage from which to view it. Federal Highway Administrator Victor Mendez describes the bypass as “a modern engineering marvel.” Here’s what the rest of the country can learn from the nine-year, \$240 million project, which somehow came in on budget. —ERIK SOFGE

1. Concrete is (still) the future.

Like the Hoover Dam’s monolithic face, the Colorado River Bridge showcases concrete: At 1060 feet, its arch is the longest in North America. When the bridge was first conceived in the 1980s, a lone concrete arch would not support projected loads, but by 2003 high-performance concrete, paired with a steel superstructure, was up to the task.

2. Big projects can leave small footprints.

Local flora, preserved in nurseries, has been replanted following construction. Engineers also cut channels under sections of U.S. 93 that were elevated to keep the road level. These animal bypasses allow desert bighorn sheep to cross beneath the roadway, reducing collisions with cars.

3. New roads are safer roads.

Accidents were three times more common on the hairpin turns and steep slopes of the old stretch than on the rest of U.S. 93. The new 5.5-mile route is essentially a straightaway, with twice as many lanes and a higher speed limit. By diverting non-tourist traffic away from the Hoover Dam and its access roads, the bypass also makes it a less tempting terrorist target.

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Upgrade

1 of 8

2011

wish list

Depth Perfection

Oh, 3D TV—we *want* to love you, but there just isn't enough 3D content on the market. One solution: Create it yourself.

The 10-megapixel **Fujifilm FinePix Real 3D W3 Camera (\$500)** uses two lenses to shoot photos and 720p HD video in 3D. And the camera is just an HDMI cord away from displaying its fourth-wall-busting creations on a 3D monitor. Don't have a 3D TV handy?

The FinePix has a 3.5-inch LCD that offers 3D viewing—without the goofy glasses. The camera's binocular vision even comes in handy in 2D mode: It can simultaneously photograph the same scene zoomed in close with one lens and from a wide angle with the other.

Our annual guide to the most-wanted tech, tools and toys shows you what to ask for—and gives you the tips you need to make the most of your holiday bounty. How's that for a stocking stuffer?

BY SETH PORGES



1 / Amazon Kindle Wi-Fi (\$140)

Even in the age of the iPad, the Kindle's well-stocked bookstore, light weight and epic battery life preserve its title as the best pure e-reader on the market. At just \$140, the new Wi-Fi-only version is a bargain; an extra \$50 gets you the download-anywhere freedom of a 3G connection.

2 / Craftsman Seven-Piece Universal Design Ratcheting Wrench Set (\$50)

The planet is full of damaged and deformed nuts and bolts. You can get a grip on them with the redesigned tooth geometry on the ratcheting box end of Craftsman's new combination wrench set.

3 / Magimix Vision Toaster (\$250)

The world's first see-through toaster is fun (watching bread brown is oddly addictive), practical (transparent toasting puts an end to burned bagels) and—we admit—ludicrously expensive.

4 / Stanley Stubby Ratcheting MultiBit Screwdriver (\$9)

This tiny driver's three-position ratchet and squat profile are perfect for tightening cabinet hardware or working in the confines of a breaker panel. The base of the handle pops open to reveal storage for six bits.



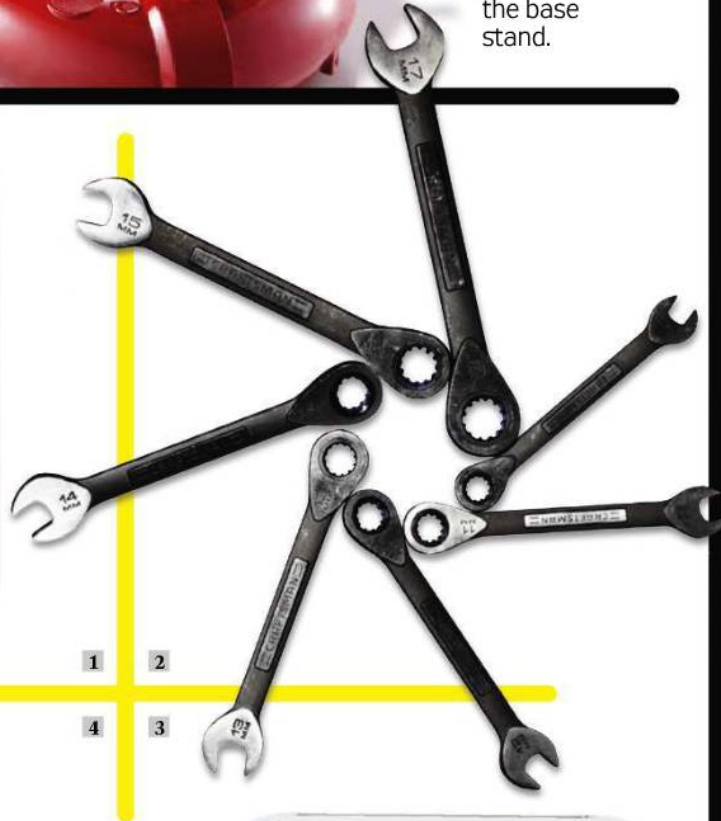
Ikyaudio Speakers (\$200) →

These unpowered desktop speakers—handmade and painted by a Chicago craftsman—are created from repurposed PVC. Each pipe houses a 3-inch driver, with a bass port jammed into the base stand.



TIP •

Cellphones can have astronomical international data fees. The Kindle's 3G connection offers free (albeit black-and-white) Web access in more than 60 countries.



UNDER \$25





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wish list

2011

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UPGRADE

TIP

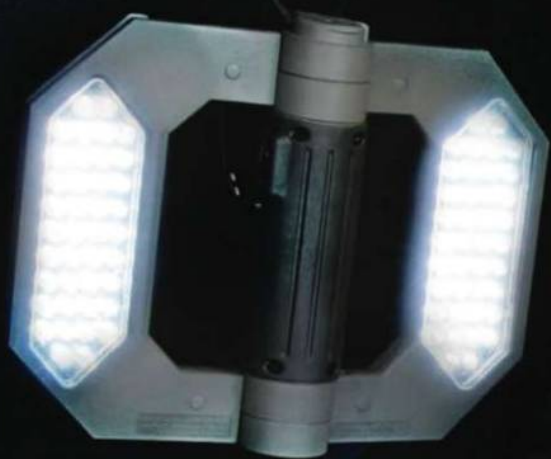
Corded recip saws have the power to rip through just about anything with even a somewhat dull blade, but weaker, cordless models need a better cutting edge for optimal performance. We suggest using fresh bimetal blades: The high-speed steel edge and spring-steel back provide more efficient slicing action and greater durability.



The Clampdown

When you're using a reciprocating saw, rattling pipes are anathema to a clean cut. The clamp built into the shoe on the **Porter-Cable 12-Volt Max Clamp Saw (\$130)** keeps a firm grip on pipes, tubing or conduit. The hinged body makes the saw handy for tasks in tight spaces.

GETTING YOUR HANDS DIRTY JUST GOT EASIER.



MIGHT D LIGHT

The Might-D-Light™ LED Folding Worklight just made your job easier. The integrated rare-earth magnets attach to most metal surfaces and the nylon swivel hook allows for hands free use. The 80 cool bright white LED lights along with the folding design allows you to aim the LEDs to light up those hard to reach places. The Might-D-Light™ is the perfect tool for the guy who isn't afraid of getting his hands dirty.

www.might-d-light.com

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and other fine retailers.

ACE



HANDY
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COOPER Lighting

1 / Nerf N-Strike Stampede ECS Blaster (\$50)

Not only is this fully automatic, bipod-mounted Nerf gun the best foam ballistics instrument on the market, but it's also easier to use and less prone to jams than previous battery-powered, rapid-fire Nerf guns. Call it a full foam jacket.



UNDER \$25

2 / Zippo Flexible Neck Utility Lighter (\$15)

The flexible neck on this rugged, wind-resistant lighter can fit into narrow grill grates and reach kindling tucked between pieces of firewood.

UNDER \$25

1 2
4 3

3 / Kodak Pulse 10-Inch Frame (\$200)

Loading digital picture frames has never been easier: Just send photos to a dedicated e-mail address and they pop up on this Luddite-friendly display. And, unlike previous versions whose screens maxed out at 7 inches, this one has a generous 10-incher.



5

4 / Tron: Legacy 7.5-Inch Action Figure (\$15)

A light-up, animated face gives this talking toy a head-turning update.



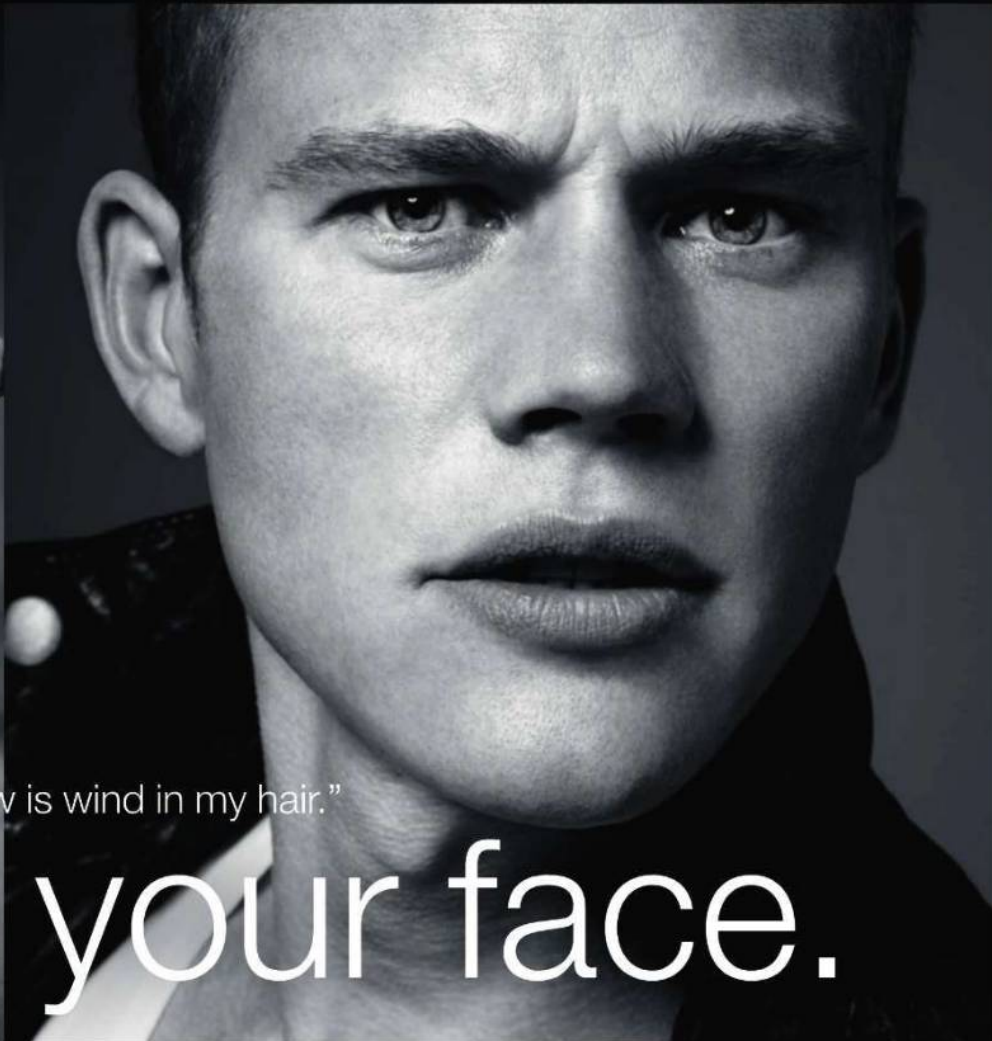
Makita 18V LXT Lithium-Ion Cordless Rotary Hammer (\$260)

Until recently, rotary hammers were brutish machines—too large and unwieldy for most household tasks. This user-friendly model weighs just 6.6 pounds and can drill holes up to $\frac{7}{8}$ inch in diameter.

TIP

A rotary hammer should eject a steady stream of pulverized concrete. If it doesn't, the tool likely has a jammed bit or is boring into something it shouldn't.

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wish list

2011

5 of 8

UPGRADE

TIP

Looking for a ready-for-anything bike toolkit? Pack an Allen wrench multitool, an adjustable wrench, an extra tire tube and a patch kit complete with levers, patches and a CO₂ pump and cartridge.



Belt-Driven Workhorse

The **Specialized Globe Live 3 Bike (\$1550)** is an urban-oriented cruiser designed for commuters and errand runners. Its front rack carries up to 55 pounds of groceries or gear, and the bike ditches a chain for a low-maintenance, rustproof carbon belt that never needs to be lubricated.

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Lead. Don't Follow.



1 / Cub Cadet 221-hp Single-Stage Snow Thrower (\$450)

An electronic ignition mechanism makes firing up this 21-inch-wide, 179-cc snow thrower a snap—even in the coldest conditions. A bale-style handle on the clog-resistant chute makes it easy to aim the output.

2 / WowWee Paper Jamz Guitar (\$25)

Like a TV-free *Guitar Hero*, this toy ax provides a push-button way to play along with preloaded songs. But the real fun is in the free-play mode, which lets aspiring Slashes kick out the jams by playing real songs with real chords. The result is real fun. Really.

3 / Emotion Comet Kayak (\$280)

This 8-foot-3-inch polyethylene solo paddler is among the toughest, most maneuverable and most stable consumer kayaks on the market—and it sells for hundreds less than comparable boats. An inflatable stern-based flotation bag ups the boat's buoyancy.

4 / Dyson Air Multiplier AM02 Tower Fan (\$450)

The original Dyson Air Multiplier fan was a blade-free marvel of engineering, but its desktop design was too small to cool much space. This free-standing tower version is large enough to move air through an entire room.

Cuisinart EasyPop Popcorn Maker (\$60)

→ The top of this popcorn machine transforms into a couch-friendly serving bowl, while the ability to easily add your own salts and oils allows for freedom of flavor.



TIP

If you live in a snowdrift-prone area or your driveway is often blocked by snow berms, opt for a two-stage snow thrower, which employs both an auger and an impeller.



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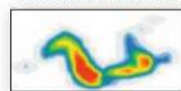
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‡Restrictions apply. See savings card for details and expiration date.
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Mile for mile, a gas-powered lawnmower produces exponentially more pollution than a car. The battery-fueled **Neuton CE5 Duracell-Powered Lawnmower (\$400 to \$500)** provides a cleaner (and quieter) way to cut smaller lawns. The 24-volt, 14-inch version can handle up to a quarter acre on a single charge; the 36-volt, 19-inch model can shear a third of an acre.



TIP

Because electric mowers have less chopping power than their gas-powered brethren, they call for a more deliberate style of use. So work at a slower pace, cut smaller swaths and pay extra attention to keeping the deck and blades clean.

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TIP .

A coarse hacksaw blade—that is, one with fewer, larger teeth—makes fast work of soft materials, such as copper and brass. A blade with small serrations is better for hard, thin metals, such as steel or sheet metal.

1 / Bosch Power Box 360S (\$250)

With 26 watts powering an omnidirectional set of four speakers and a subwoofer, this job-site-friendly sound system could drown out the whine of a circular saw. The sturdy frame stands up to major abuse, and multiple outlets provide juice for power tools.

2 / Milwaukee Compact Hacksaw (\$12)

Bare hacksaw blades are problem-solving skeleton keys, but they're hard to grip when severing the shanks of stripped screws. This cushy saw offers a comfortable handle for quick jobs, and a tool-free blade clamp makes it easy to pull a blade into tension.

3 / Audyssey SoMa Audio Dock (\$400)

Movie theaters routinely turn to Audyssey to calibrate their sound. The company's first consumer product incorporates theater-worthy sound-calibration algorithms—which, among other things, make sounds swell at low volumes—into a dual-woofer and dual-tweeter iPhone dock.

4 / Samsung DualView ST100 Camera (\$350)

Last year, Samsung introduced digital cameras with front-facing LCDs—a boon to self-photographers. This update retains that feature, ups the LCD screen size to 1.8 inches and fits the 5x zoom lens into the body for a slimmer profile.



Ducati Superbike 848 Evo (from \$13,000) → This sportbike might handle like a smaller-class motorcycle, but its 140-hp desmodromic engine, trellis frame and Brembo monobloc give it a performance that's usually reserved for much larger bikes.



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Motown is back. After a disastrous 2009, when GM and Chrysler nearly imploded, the Detroit Three nabbed the majority of this year's Automotive Excellence awards—in a market that's more competitive than ever. Our decision process was straightforward: After each new-car test drive, we recorded the vehicle's functionality, technology and value—and what it was like from behind the wheel. Then we gathered and passionately argued over our favorites. It's not easy—we take our debates seriously—but we stuck to it. Presenting the best cars and trucks of 2011.

POPULAR MECHANICS
TOP 10 CARS

←

AUTOMOTIVE

New Cars
EXCELLENCE AWARDS 2011

N

O BRAND IS MORE DEEPLY ROOTED IN OFF-ROAD ADVENTURE than Jeep. The new Grand Cherokee stands at the top of the lineup with not only a much more luxurious and roomy interior but also more power and, yes, enhanced on- and off-road chops. The new 3.6-liter Pentastar V6 churns out 290 hp and 260 lb-ft of torque, delivers 16 mpg city and 23 mpg highway and will tow 5000 pounds. But we'd choose the 360-hp V8 for its muscle-car hustle—and take the modest fuel-economy hit. For the first time, the unibody Jeep uses a four-wheel independent suspension for enhanced steering and suspension precision. Opt for the Quadra-Lift air suspension, and the Jeep will provide five distinct suspension-height levels, with up to an impressive 10.7 inches of ground clearance. During a snow-covered sortie in Moab, Utah, the Jeep rocked and rolled its way over the worst obstacles, taking the most challenging lines without so much as a whimper. Best of all, the Grand Cherokee can lower itself back down and provide a pillow-soft luxury-car ride on the way home from the trailhead.

2011
JEEP GRAND
CHEROKEE

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Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation



2011 LOTUS EVORA

↓ BASE PRICE: \$74,675

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

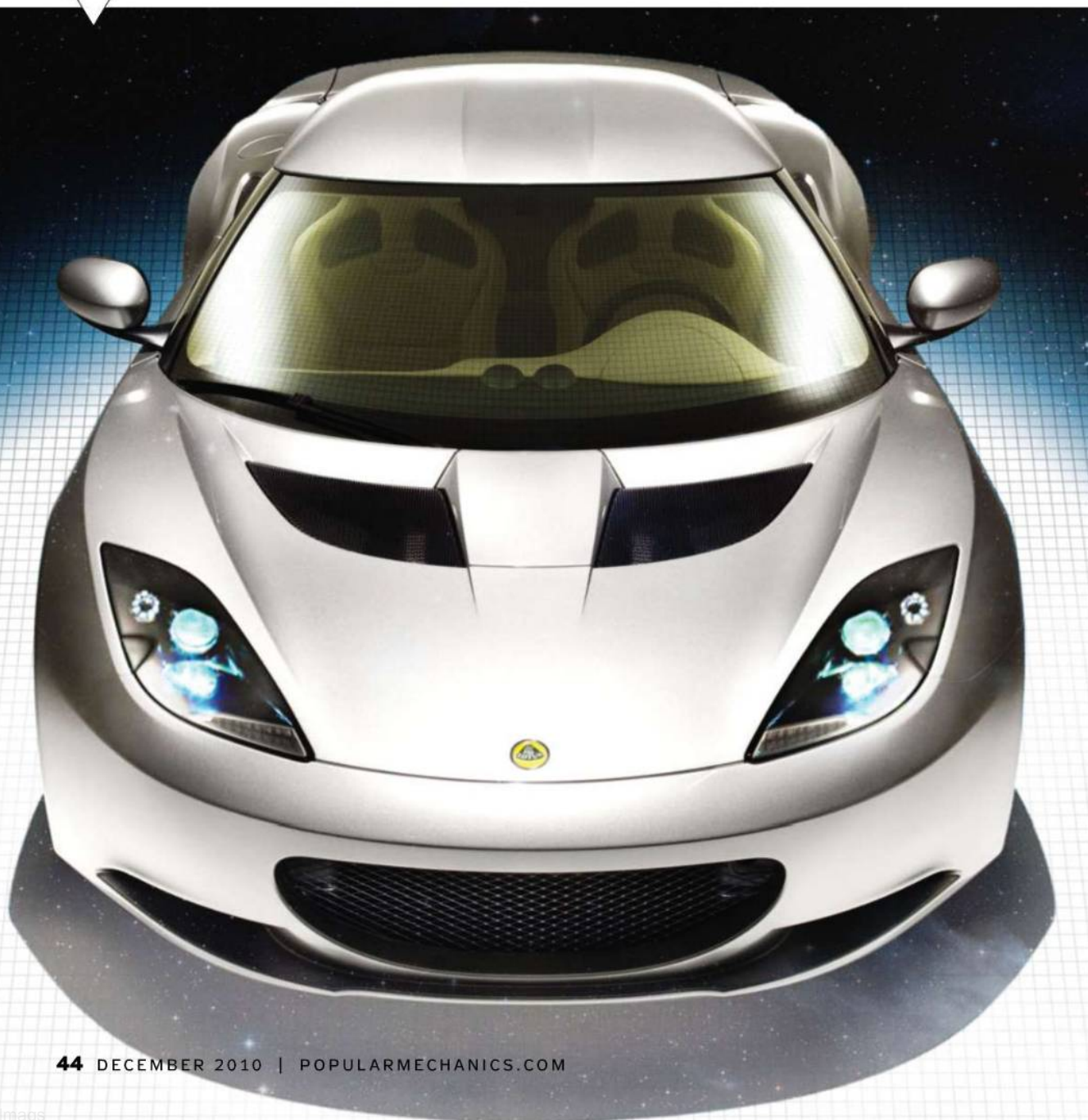
Design

Luxury

Technical Innovation

WT

HAT DOES LOTUS KNOW ABOUT HANDLING that eludes the rest of the world? It's a question we asked ourselves after an exhilarating mountain-road romp in the new Evora. While this Lotus makes several concessions to practicality, such as a small rear seat and even cruise control, essentially it's a driver's car. And for 2011, there's nothing better on the road. Those with the means will enjoy a connection between the car and the road that borders on telepathic. The steering effort linearly increases as the cornering forces build, and the suspension impeccably keeps the tires squarely planted on the road. The result is a car with high but accessible cornering limits, a sports car that makes even novice drivers feel like heroes. Even better, the Evora smashes the notion that good handling and a supple ride are mutually exclusive—it's cushy enough to drive to work, yet incredibly entertaining on curvy roads and racetracks.



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Versatility

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↓ BASE PRICE:
\$25,270

While minivans are often passed over in favor of crossovers and SUVs, no vehicle is more versatile. Witness the new Toyota Sienna. It's 5 inches shorter than the Toyota Sequoia, yet the Sienna offers 39.1 cubic feet of cargo room behind the third-row seat, 20.2 more than the sport ute. Furthermore, the Sienna's seats adapt to a variety of configurations. The split third row folds flat into the recessed cargo area, and the second row—either singular buckets or a split bench—slides fore and aft and also folds. For 2011, Toyota offers a 2.7-liter four-cylinder and a six-speed automatic that return up to 24 mpg. The company has also aggressively restyled the van in an attempt to drop some of the mommy-mobile stigma. Need more proof that the Sienna can do it all? It tows up to 3500 pounds and is the only minivan that's available with all-wheel drive.

2011 HYUNDAI SONATA

↓ BASE PRICE: \$19,195

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

IN PRO SPORTS, THE MOST VALUABLE PLAYER trophy doesn't always go to the player with the best stats; sometimes, intangibles add up to an obvious MVP. Similarly, the Hyundai Sonata was a clear choice for the 2011 PMV—POPULAR MECHANICS's Value—award. What Hyundai has achieved with the redesign of its bread-and-butter sedan is, in a word, astonishing. One glance tells much of the story, as the vehicle looks more like a luxury coupe than a midsize economy sedan. Gone is the V6, replaced with a 200-hp four-cylinder. Or opt for a turbocharged four-banger with 274 hp, which makes you forget about the lack of a V6 in the lineup. There's even a hybrid model that gets over 30 mpg. Options aside, the Sonata's standard safety equipment includes electronic stability control (ESC), traction control and antilock brakes with brake assist. Throw in Hyundai's 10-year, 100,000-mile warranty and it makes you wonder what luxury carmakers will have to do to keep calling themselves luxury carmakers.

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2011 FORD MUSTANG

↓ BASE PRICE: \$22,145

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

LAST YEAR, WE PICKED THE FORD Mustang Shelby GT500 as the best performance car, and we didn't expect to bestow the honor on the original ponycar again for quite some time. After all, the performance category is brimming with dynamic-handling, powerfully motivated competitors from around the globe—the BMW M3 and the Chevrolet Corvette were recent winners—and they're all improving, all the time. But over the course of the past few months, Ford has re-energized the entire Mustang lineup. First, the new GT arrived with an astonishingly versatile V6 engine that developed 305 hp while attaining more than 30 mpg. Alongside that entry-level engine, we witnessed the rebirth of the 5.0, a nostalgic number that represents high performance—by virtue of its 412 hp—like none other. Except, perhaps, for the 302. Ford reincarnated the Boss 302 nameplate for 2011 as a naturally aspirated 440-hp race car you can drive to the racetrack. You can manually tune the adjustable shocks to their hardest settings, win the race, and then revert to the softer street settings and drive home. Finally, the 2011 Shelby GT500 still sits at the extreme side of the spectrum, featuring a new, lighter aluminum block for its supercharged 5.4-liter V8 (which makes 550 hp and 510 lb-ft of torque). Race ya' for pinks?



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2011 FORD F-250 SUPER DUTY

↓ BASE PRICE: \$28,020

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

W

WHEN THERE'S A HEAVY LOAD TO MOVE—AND MOVE QUICKLY—few vehicles will do it better than Ford's new Super Duty pickups. The heart of a truck is its powerplant, and the top choice for these rigs is the new 6.7-liter diesel V8 that cranks out 400 hp and a pavement-wrinkling 800 lb-ft of torque. That's more grunt than any other pickup or passenger vehicle sold in North America. Indeed, an F-350 dually can handle over 7000 pounds in its bed and tow more than 22,000 pounds with a fifth-wheel hitch. When the road gets muddy, there's a solid axle at each end of a 4WD Super Duty's chassis—and an optional electronic locking rear differential to split power equally to the rear wheels. The new Super Duty is exceedingly capable on the job site, but it was the truck's docile road manners that helped it win our heavy-duty pickup truck comparison test (Nov. '10). For 2011, the suspension was reconfigured to use fewer leaf springs in the back, which helps these massive trucks soak up the bumps like an F-150, and the light steering effort eases trailer backups. The Super Duty continues Ford's use of pioneering and smart options, like power-extendable towing mirrors, flip-up rear seats and an innovative productivity screen, that make the dirtiest jobs seem almost, well, fun.

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2011 FORD FIESTA

↓ **BASE PRICE: \$13,320**

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

JUST ABOUT ANYBODY CAN MAKE A CAR FUEL EFFICIENT WITH the aid of an electric motor, a generator or two and a few hundred lithium batteries. But it takes some real skill to achieve up to 40 mpg—and a 400-mile range—from a good ol'-fashioned internal combustion engine. Not that the Ford Fiesta is exactly old-fashioned. After all, it comes with a dual-clutch transmission and electric power-assisted steering, and its 1.6-liter 16-valve four-cylinder Duratec generates 120 hp with the help of variable-cam timing. In the interest of full disclosure, however, the really remarkable mileage figure is achieved when customers elect to ditch the five-speed manual transmission and spend another \$1070 to pair the engine to the optional PowerShift, a six-speed dual-clutch automatic that boosts the car's EPA mileage ratings to 29 mpg city/40 mpg highway. The dual-clutch gearbox is a technology that emerged on the \$1 million Bugatti Veyron in 2005, then gradually made its way into sporty cars from Audi, BMW, Ferrari, Nissan, Porsche and the like for its responsiveness and seamless gear changes. This is its first appearance in the subcompact sedan and hatchback market. Because there is no fancy hybrid or electric tech to finance, the payoff is immediate: The dual-clutch Fiesta costs thousands less than a Honda Insight or Toyota Prius.





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2011 INFINITI M37/M56

↓ BASE PRICE:
\$47,125

Every rear-drive Infiniti since the original 2003 G35 has been exceptionally fun to drive—and to its rivals, a formidable competitor. But in terms of polish, the company's cars have lagged behind Europeans. No more. Inside and out, the 2011 Infiniti M could set new benchmarks for design. The sedan retains the taut handling of past models, but thanks to a suspension reboot, it now moves with more finesse. The M also boasts smart technology such as Lane Departure Prevention—which activates the brakes to keep the M in its lane—and the Eco Pedal, an accelerator that resists throttle jabs, reminding the driver how to save fuel. The M37's potent 3.7-liter V6 brings 330 hp, and Infiniti's new 420-hp 5.6-liter V8 is a powerhouse. Next year, the M Hybrid will be about 25 percent more efficient than the current M37—and deliver 40 more lb-ft of torque than the M56.

2011 CADILLAC CTS COUPE

↓ BASE PRICE: \$38,165

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

IT WOULD HAVE BEEN LESS COMPLICATED FOR General Motors to do what car companies usually do when introducing new vehicles to the buying public: trot out a stunningly beautiful concept at an auto show, only to tone down the production version before it makes its way to market. It's the old design-to-reality bait-and-switch. The production version of the CTS Coupe gives Cadillac's "Art and Science" design language a refined accent—the edges are still there, but they're tempered with curves that convey a handcrafted look. Of course, the CTS Coupe owes much of its design to the CTS Sedan, including the entirety of its bold front end. Unlike the sedan, however, the Coupe's profile is perhaps its best angle—with a swept windshield, blacked-out B-pillars and nearly horizontal rear glass that breathes new life into what is usually a banal perspective. Note the lack of exposed door handles, the center-mounted exhaust and the upright taillights that hark back to Cadillac's tail fins from 1948. Now drool.



When machines start driving machines we'll consider a change.

Computers can measure performance. But computers can't feel. They don't have a pulse. Which is why Infiniti has a Master Driver, recognized by the Ministry of Japan for his extraordinary skill. His sole job is to provide engineers with human feedback. Emotional feedback. One drive in a G Sedan, Coupe, Convertible or the new G25 Sedan, and you'll instantly feel the exhilarating difference he makes. This is inspired performance. This is the way of Infiniti.



Learn more about the new G25 and the remarkable G Line at InfinitiUSA.com.

Vehicle shown is G37 with Sport Package. Always wear your seat belt, and please don't drink and drive. ©2010 INFINITI.



Shodo art by Masako Inkyo



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2011 CHEVROLET VOLT

↓ BASE PRICE: \$41,000

Off-Road Ability

Fun to Drive

Value

Versatility

Performance

Workhorse

Fuel Efficiency

Design

Luxury

Technical Innovation

A

AFTER MORE THAN 300 MILES BEHIND THE WHEEL OF GM'S technical marvel, we remain impressed. GM reps call the Volt an EV with a range extender because its prime motivation comes from a 16-kilowatt-hour lithium-ion battery pack that users can charge from an outlet before driving. Once the battery is depleted, a 1.4-liter four-cylinder gas engine spins a generator so drivers never have to worry about being stranded with a flat battery. In practice, the Volt hides its high-tech underpinnings in a refined, smooth and practical everyday machine that's unlike anything else on the road. With a charged battery, the only sounds the car makes are faint electronic hums and buzzes and hushed tire noise. The backup engine fires with a barely perceptible shudder and only gets raucous during hard driving. While GM claims the Volt can travel up to 40 miles on a fully charged battery, we never got farther than 35 before the engine fired. Once the battery was discharged, the Volt returned 31.72 mpg in the city and 36 on the highway—decent but far from stellar results. But as GM works on Volt 2.0, surely those figures will improve. More to the point, it represents a dramatic re-engineering of the automobile that will change the way people think about electric cars.

++ **PM
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HORSEPOWER: 150 /// WEIGHT: 3790 POUNDS /// ACCELERATION (SEC) / 0-60 MPH: 8.82 /
QUARTER-MILE: 16.51 @ 86.43 MPH /// BRAKING (60-0 MPH): 118.97 FEET /// EV RANGE: 33.1 MILES
/// PM FUEL ECONOMY (WITH BATTERY DISCHARGED) CITY: 31.72 MPG / HIGHWAY: 36 MPG

ARE YOU KIDDING YOURSELF?

A LOT OF PEOPLE THINK EXERCISE AND HEALTHY DIET ARE ENOUGH TO LOWER HIGH CHOLESTEROL. FOR 2 OUT OF 3, IT MAY NOT BE.

Did you know, more than 80% of people who have had heart attacks have high cholesterol? For 2 out of 3 people with high cholesterol, diet and exercise may not be enough. If you haven't been successful in trying to lower your cholesterol on your own, stop kidding yourself. Talk to your doctor about your risk and if Lipitor is right for you. You can also learn more at lipitor.com or call 1-888-LIPITOR.

- When healthy diet and exercise are not enough, adding Lipitor may help.
- Along with diet, Lipitor has been shown to lower bad cholesterol 39-60% (average effect depending on dose) and Lipitor is FDA-approved to reduce the risk of heart attack and stroke in patients who have heart disease or risk factors for heart disease. These risk factors include smoking, age, family history of early heart disease, high blood pressure and low good cholesterol.

IMPORTANT SAFETY INFORMATION: LIPITOR is not for everyone. It is not for those with liver problems. It is not for women who are nursing, pregnant or may become pregnant.

If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose.

Common side effects are diarrhea, upset stomach, muscle and joint pain, and changes in some blood tests.

INDICATION:

LIPITOR is a prescription medicine that is used along with a low-fat diet. It lowers the LDL ("bad" cholesterol) and triglycerides in your blood. It can raise your HDL ("good" cholesterol) as well. LIPITOR can lower the risk for heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as age, smoking, high blood pressure, low HDL, or family history of early heart disease.

LIPITOR can lower the risk for heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking or high blood pressure.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.



LIPITOR[®]
atorvastatin calcium
tablets

Please see additional important information on next page.

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DON'T KID YOURSELF

lipitor.com

IMPORTANT FACTS



LIPITOR
atorvastatin calcium
tablets

(LIP-ih-tore)

LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack and stroke. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, family history of early heart disease

LIPITOR can lower the risk of heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems.** Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Call your doctor right away if you have:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
- Allergic reactions including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing which may require treatment right away
- Nausea, vomiting, or stomach pain
- Brown or dark-colored urine
- Feeling more tired than usual
- Your skin and the whites of your eyes turn yellow
- Allergic skin reactions

Common side effects of LIPITOR are:

- Diarrhea
- Muscle and joint pain
- Upset stomach
- Changes in some blood tests

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to www.lipitor.com or call 1-888-LIPITOR.

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Eighty-six years ago, a watchmaker in Paris famous for building the magnificent clocks at Versailles created a legendary timepiece. He invented the first watch with an automatic mechanical drive. These innovative movements required no batteries and never needed to be manually wound. Only seven of these ultra-rare watches were ever made and we've studied the one surviving masterpiece in a watch history museum. Inspired by history, classic design and technology, our Stauer *Meisterzeit* has been painstakingly handcrafted to meet the demanding standards of vintage watch collectors.

Why the new "antique" is better than the original. The original timepiece was truly innovative, but, as we studied it closely, we realized that we could engineer ours with a much higher level of precision. The 27-ruby-jewel movement utilizes an automatic self-winding mechanism inspired by a patent from 1923, but built on \$31 million in state-of-the-art Swiss-made machinery. With an exhibition back, you can see into the heart of the engineering and view the rotor spin—it's powered by the movement of your body.

This limited edition Stauer *Meisterzeit* allows you to wear a watch far more exclusive than most new "upscale" models. Here is your chance to claim a piece of watchmaking history in a rare design that is priced to wear everyday.

Elegant and accurate. This refined beauty has a fastidious side. Each movement and engine-turned rotor is tested for 15 days and then certified before it leaves the factory.

The best part is that with our special price, you can wear a superb classic historical reproduction watch and laugh all the way to the bank. Stauer specializes in classic timeless watches and jewelry that are made for the millionaires who want to keep their millions. This watch will quickly move to heirloom status in your household.



View the precision movement of the *Meisterzeit* through the rear exhibition port.

Try it for 30 days and if you are not thrilled with the beauty and construction of the *Meisterzeit*, simply return it for a refund of the purchase price.

Extremely limited availability. Since it takes about 6 months to build each watch, the release is a limited edition, so please be sure to order yours soon.

WATCH SPECS:

- 14K Gold-clad case and bezel
- Precision 27-jeweled movement
- Interior dials display day and month
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- Fits 6 3/4"–8 1/4" wrist

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THE SHIPPING NEWS

> BY GLENN DERENE
> PHOTOGRAPHS BY JAMES WORRELL

WE SENT A BUNCH OF SENSORS ON AN EPIC JOURNEY TO DETERMINE WHICH SHIPPING COMPANY IS KINDEST TO YOUR PACKAGES.

A

few years ago, POPULAR MECHANICS shipped a custom-built gaming PC—a rather heavy and cumbersome beast—to a New Hampshire woman who'd won it in a sweepstakes. The computer arrived in pieces, delivering a crushing blow, so to speak, to the nice lady as well as to the PM staffers who'd built the computer. Even though we made good by reconstructing the PC and driving it to her doorstep, I still shudder at the memory of the gory photos she sent us of the shattered machine.

The overnight-shipping industry is a modern technological and logistical wonder, but it still can inflict medieval damage on parcels. Everyone has at one time or another received a dented, torn or otherwise mutilated package. And after our PC-shipping incident, I felt a sense of professional duty to find a way to get inside a package, as it were, and quantify the abuse it endures. Since my life insurance would become null and void if I

attempted to ship myself, I needed a technological solution.

This sort of tech exists. Last fall, FedEx introduced a service for critical packages called SenseAware, which tracks vibration, g-force, orientation, temperature and other factors. But I didn't want to use SenseAware for the test because it's unavailable to the general public—and besides, I had a



Thinking Inside the Box

We worked with National Instruments, an industrial test and measurement company, to create a data-logging device that could gauge and record vibration, temperature and orientation. Here's our package at the end of its journey.

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Imagine not being tired anymore. Imagine being pain free and filled with energy.

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- Elevate your performance

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Extra weight puts an added toll on your bones and joints. Running isn't an option, and walking can become difficult.

G-Defy Shoes will take the pressure from your large frame body, make you more active and change your life forever!



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You will notice immediate relief of common pain during exercise as the springs of G-Defy athletic shoes absorb most of the impact—instead of your body—by easing the stress on your joints, back and neck while walking, running, or jumping.



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Twin Stabilizers

Smart MemoryTM Master Spring Propels you forward and reduces fatigue

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Rugged Polymer Sole



a \$129.95 value

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sizes 7 - 13
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sizes 5 - 11
Med/Wide and ExtraWide/XXWide Widths



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P M



covert mission in mind.

I called up a contact at National Instruments—an innovative manufacturer of industrial control equipment and software, based in Austin, Texas—and presented a challenge: Could the company help me disguise vibration sensors inside a package that I could secretly ship around the country? I soon got a call from National Instruments engineers Kelly Rink, Jamie Brettle and Rick Kuhlman, who agreed to build for me a

self-powered data logger equipped with an ARM microcontroller evaluation board, a three-axis accelerometer and a massive Energizer Energi To Go XP18000 battery.

The device they created was capable of measuring acceleration, orientation and temperature. But the task wasn't a slam-dunk. "Having a processor constantly awake and writing to an SD card takes a toll on a battery," Brettle says. "But by modifying our LabVIEW code, we were able to put the processor to sleep and selectively write to the SD card. That got us 74 hours of battery life." That's enough juice to gather data from a three-day trip. We were in business.

The Plan

➔ I mapped out for our package a tour of the United States, starting and ending at POPULAR MECHANICS's home office, in New York City, with stops at our West Coast headquarters, in Santa Monica, Calif., and National Instruments', in Austin. At each stop, the data was uploaded from a micro SD card, the battery recharged and the package sent on its way. The parcel was shipped a dozen times (we had neither the time nor the budget to make the hundreds of trips necessary for statistical significance), a modest experiment to see how the device performed and gather enough data to draw broad conclusions.

Our targets—FedEx, UPS and the U.S. Postal Service—were unaware of the test. As we went along, we changed up a few variables to see if the treatment of our package changed as well. Was overnight shipping more or less violent than three-day? Did marking the package "Fragile" or

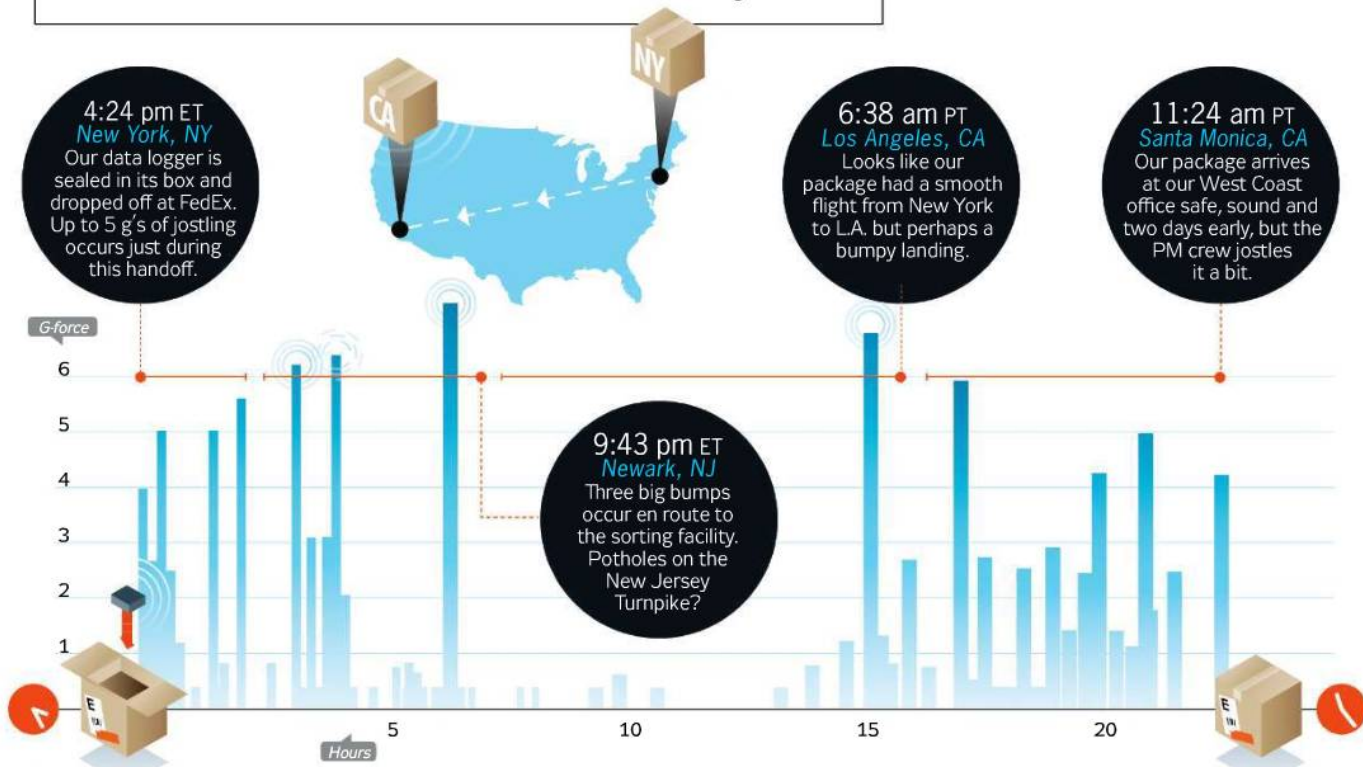


NOV. 18–19 NEW YORK, NY–SANTA MONICA, CA

FEDEX

A DAY IN THE LIFE OF A PACKAGE

What does it feel like to be a package traveling across the U.S.? Our test parcel logged 12 trips from New York City to Santa Monica, Calif., to Austin, Texas. This coast-to-coast journey was a good example of both quick service and rough handling, with four acceleration spikes over our designated 6-g threshold. Here, we've correlated the time code from our sensor with FedEx's tracking info.



SHIPPING FACTS:
The Weird and the Wonderful

➔ **The USPS outlawed** the mailing of construction materials after a man building a house in Alaska found it was cheapest to send every brick by U.S. mail. ➔ **Throughout UPS's 103 years** in business, the company has encountered several attempts by civilians to ship themselves—all unsuccessful. ➔ **FedEx's custom** black-and-white-painted Panda Express planes have shuttled multiple bears back and forth from Chinese to American zoos.

"This Side Up" ensure more careful treatment?

Before the first journey, the National Instruments engineers collected baseline g-force readings. "We dropped the package from different heights, kicked it around our building, ran down the stairs with it in a backpack and took it on a car ride—giving real-world meaning to how many g's the package endured," says Kuhlman. The findings: A moderate jostle exerts 2 g's, while a 2.5-foot drop registers 6 g's; we set the latter as our limit for rough treatment. "Our co-workers thought we were a bit odd," says Brettle, "but we assured them it was all in the name of science."

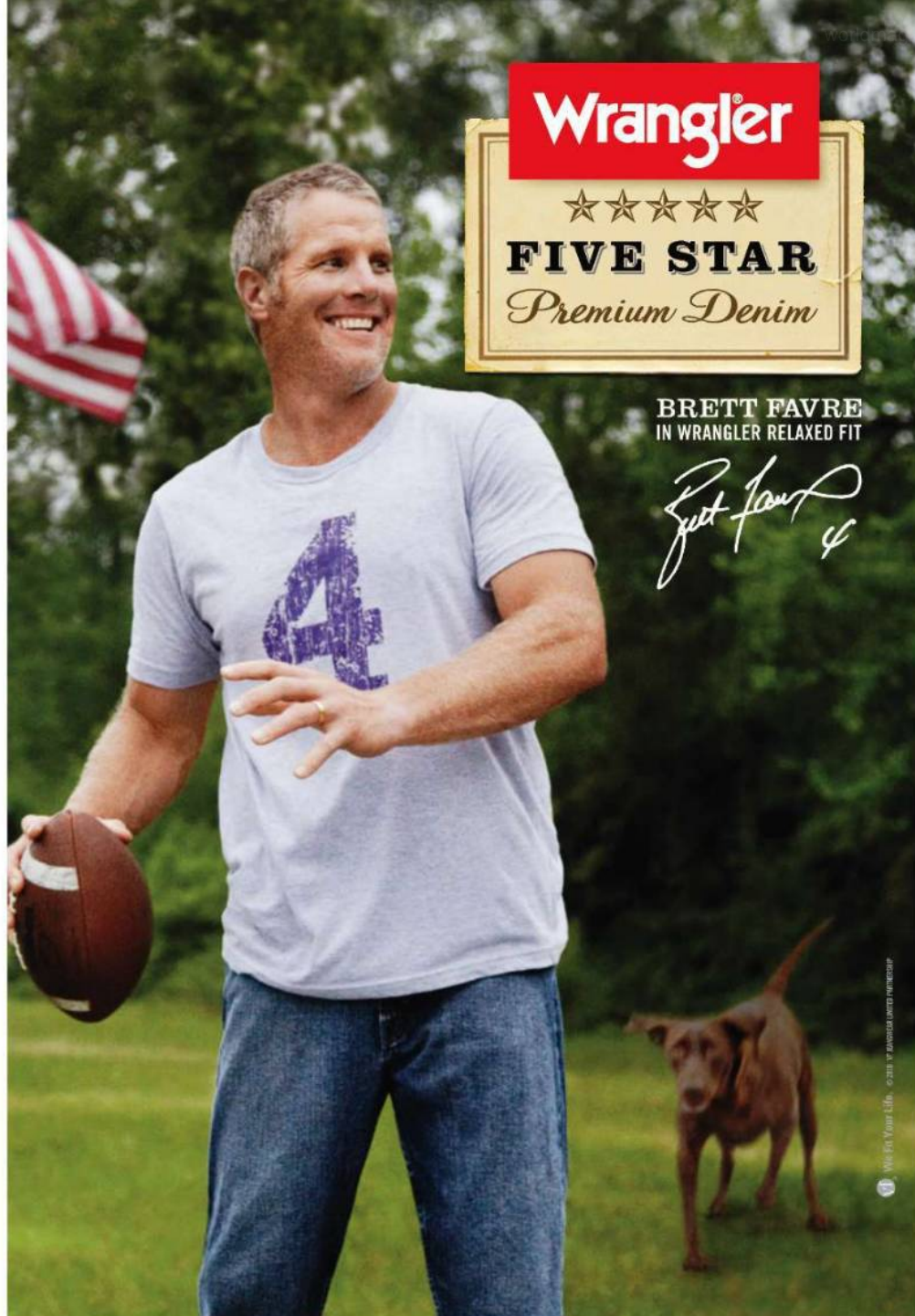
The Results

➔ **So which company** treats your packages with the most tender loving care? After crunching the data and averaging the number of spikes recorded by each carrier on each trip, we found that the USPS has the gentlest touch, with a per-trip average of 0.5 acceleration spikes over 6 g's. FedEx and UPS logged an average of three and two big drops per trip, respectively (see graph, next page).

Given those results, we were a little surprised to find that the USPS flipped over its Express Mail packages an awful lot, averaging 12.5 position changes per trip. Meanwhile, FedEx averaged seven position changes, and UPS had an average of four.

All three carriers did a good job at maintaining a stable temperature, but FedEx nabbed the top rating, with an average change of only 26.01 degrees, compared with 26.8 degrees for UPS and almost 32 degrees for the USPS. But the maximum temperatures our package experienced were within 2 degrees, and at no time did a temperature register above 80 degrees or below 47 degrees.

One disheartening result was that our package received more abuse when marked "Fragile" or "This Side Up." The carriers flipped



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P M



the package more, and it registered above-average acceleration spikes during trips for which we requested careful treatment.

Just Asking

➔ **When we were done**, I called the carriers for comment. All described the shock-absorbing technologies used in their sorting facilities, and one spokesperson felt compelled to say that the shipping industry is an “industrial” environment. I was surprised to learn that, although the USPS uses its own sorting and delivery systems, Express Mail flies via

FedEx. So our package experienced both the most and the least abuse while on the same airline. This raised an unanswerable question: Does the USPS have white-glove handling that offsets FedEx's turbulent planes, or did our package just happen to catch a few smooth rides?

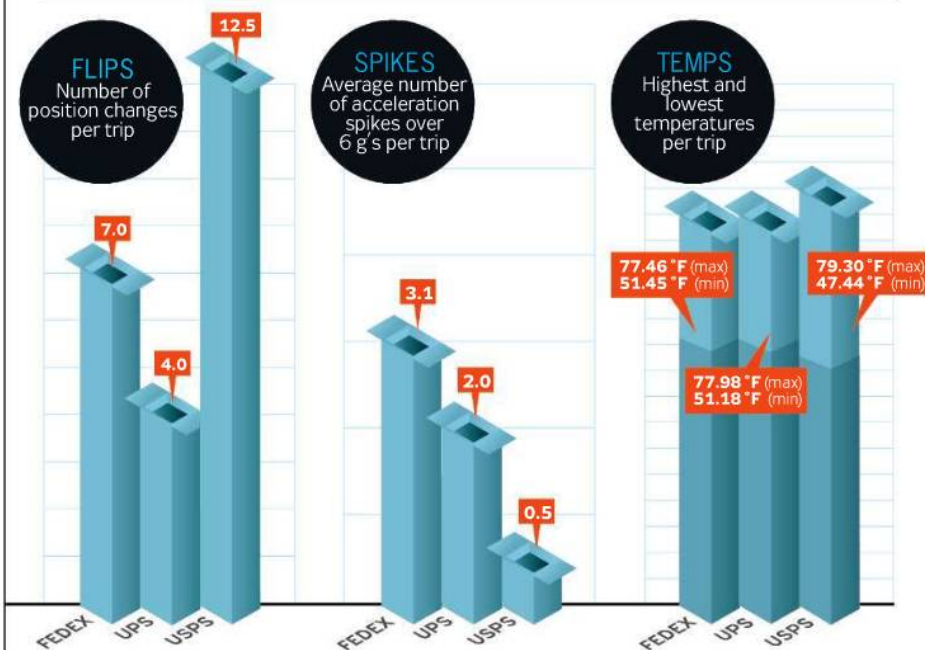
One bright finding of our test was the reliability of the service. In fact, several of our three-day deliveries arrived early. Quick delivery is what you expect—and pay for—but is gentle treatment as well too much to ask for? Kuhlman said it best in an e-mail to me: “Shipping overnight is expensive. For the price you pay, I feel like they should be rushing the package on a silver platter in a little butler's tuxedo.” Thanks to the test, I have an answer for Kuhlman: Dream on. **PM**



GRAPHIC VIOLENCE

HOW THE CARRIERS PERFORMED

How does the data stack up? In our modest experiment—12 trips, three carriers, three cities—FedEx delivered the most big bumps, with an average of three acceleration spikes over 6 g's (equivalent to a 2.5-foot drop) per trip. The USPS was the gentlest yet also the most active handler, with an average 12.5 position changes per trip. UPS was tops at keeping our package upright.



➔ **Scorpions are the only** poisonous critters shippable by USPS; they must be for research and clearly labeled “live scorpions.” ➔ **UPS has an ocean shipping** service that makes it possible to deliver, for instance, a beluga whale to an aquarium. ➔ **UPS will not ship** human body parts, but FedEx and USPS will—for legit medical purposes. — **TARAH KNARESBORO**

WHETHER YOUR WINDOWS LOOK OUT ON BIG SKIES OR
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Yes, mermaids. Just go with us on this one.



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**REDUCE
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ROOT CAUSE
TO A MORE
MANAGEABLE SIZE**



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Gout's root cause is high uric acid.

If you have gout, high uric acid can lead to more attacks. To help reduce attacks, lower your uric acid.

ULORIC can help.

ULORIC is clinically proven to help lower uric acid to a healthy level (less than 6 mg/dL).

Struggling with gout?

Ask your doctor how ULORIC can help lower uric acid and bring gout's root cause down to a more manageable size.

Use of ULORIC

ULORIC is a prescription medicine used to lower blood uric acid levels in adults with gout. ULORIC is not for the treatment of high uric acid without a history of gout.

Individual results may vary.

Important Safety Information

- Do not take ULORIC if you are taking Azathioprine, Mercaptopurine, or Theophylline.
- Your gout may flare up when you start taking ULORIC; do not stop taking your ULORIC even if you have a flare. Your healthcare provider may give you other medicines to help prevent your gout flares.
- A small number of heart attacks, strokes, and heart-related deaths were seen in clinical studies. It is not certain that ULORIC caused these events.
- Tell your healthcare professional about liver or kidney problems or a history of heart disease or stroke.
- Your healthcare professional may do blood tests to check your liver function while you are taking ULORIC.
- The most common side effects of ULORIC are liver problems, nausea, gout flares, joint pain, and rash.

Please see accompanying Important Patient Information for ULORIC on adjacent page and talk to your healthcare professional.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.



Learn More

Use ScanLife or text GOUT to 299669. You can also download a QR-Code Reader at www.2dscan.com.

Message and data rates may apply.
May not be available on all devices.

For more information, visit www.ULORIC.com or call 1-877-ULORIC-6.


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tablets

PATIENT INFORMATION

ULORIC® (Ū-'lor-ik) (febuxostat) tablets



Read the Patient Information that comes with ULORIC before you start taking it and each time you get a refill. There may be new information. This information does not take the place of talking with your healthcare provider about your medical condition or your treatment.

WHAT IS ULORIC?

ULORIC is a prescription medicine called a xanthine oxidase (XO) inhibitor, used to lower blood uric acid levels in adults with gout.

It is not known if ULORIC is safe and effective in children under 18 years of age.

WHO SHOULD NOT TAKE ULORIC?

Do not take ULORIC if you:

- take Azathioprine (Azasan®, Imuran®)
- take Mercaptopurine (Purinethol®)
- take Theophylline (Theo-24®, Elixophyllin®, Theochron®, Theolair®, Uniphyll®)

It is not known if ULORIC is safe and effective in children under 18 years of age.

WHAT SHOULD I TELL MY HEALTHCARE PROVIDER BEFORE TAKING ULORIC?

Before taking ULORIC tell your healthcare provider about all of your medical conditions, including if you:

- have liver or kidney problems
- have a history of heart disease or stroke
- are pregnant or plan to become pregnant. It is not known if ULORIC will harm your unborn baby. Talk with your healthcare provider if you are pregnant or plan to become pregnant.
- are breast-feeding or plan to breast-feed. It is not known if ULORIC passes into your breast milk. You and your healthcare provider should decide if you should take ULORIC while breast-feeding.

Tell your healthcare provider about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. ULORIC may affect the way other medicines work, and other medicines may affect how ULORIC works.

Know the medicines you take. Keep a list of them and show it to your healthcare provider and pharmacist when you get a new medicine.

HOW SHOULD I TAKE ULORIC?

- Take ULORIC exactly as your healthcare provider tells you to take it.
- ULORIC can be taken with or without food.
- ULORIC can be taken with antacids.
- Your gout may flare up when you start taking ULORIC, do not stop taking your ULORIC even if you have a flare. Your healthcare provider may give you other medicines to help prevent your gout flares.
- Your healthcare provider may do certain tests while you take ULORIC.

WHAT ARE THE POSSIBLE SIDE EFFECTS OF ULORIC?

Heart problems. A small number of heart attacks, strokes and heart-related deaths were seen in clinical studies. It is not certain that ULORIC caused these events.

The most common side effects of ULORIC include:

- liver problems
- nausea
- gout flares
- joint pain
- rash

Tell your healthcare provider if you have any side effect that bothers you or that does not go away. These are not all of the possible side effects of ULORIC. For more information, ask your healthcare provider or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to the FDA at 1-800-FDA-1088.

HOW SHOULD I STORE ULORIC?

Store ULORIC between 59°F - 86°F (15°C - 30°C).

Keep ULORIC out of the light.

Keep ULORIC and all medicines out of the reach of children.

GENERAL INFORMATION ABOUT THE SAFE AND EFFECTIVE USE OF ULORIC.

Medicines are sometimes prescribed for purposes other than those listed in a patient information leaflet. Do not use ULORIC for a condition for which it was not prescribed. Do not give ULORIC to other people, even if they have the same symptoms that you have. It may harm them.

This patient information leaflet summarizes the most important information about ULORIC. If you would like more information about ULORIC talk with your healthcare provider. You can ask your healthcare provider or pharmacist for information about ULORIC that is written for health professionals. For more information go to www.uloric.com, or call 1-877-825-3327.

WHAT ARE THE INGREDIENTS IN ULORIC?

Active Ingredient: febuxostat

Inactive ingredients include: lactose monohydrate, microcrystalline cellulose, hydroxypropyl cellulose, sodium croscarmellose, silicon dioxide, magnesium stearate, and Opadry II, green



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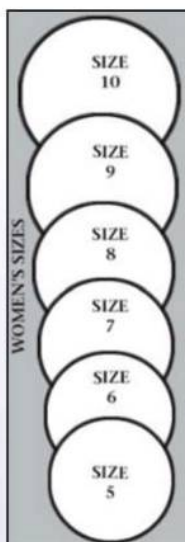


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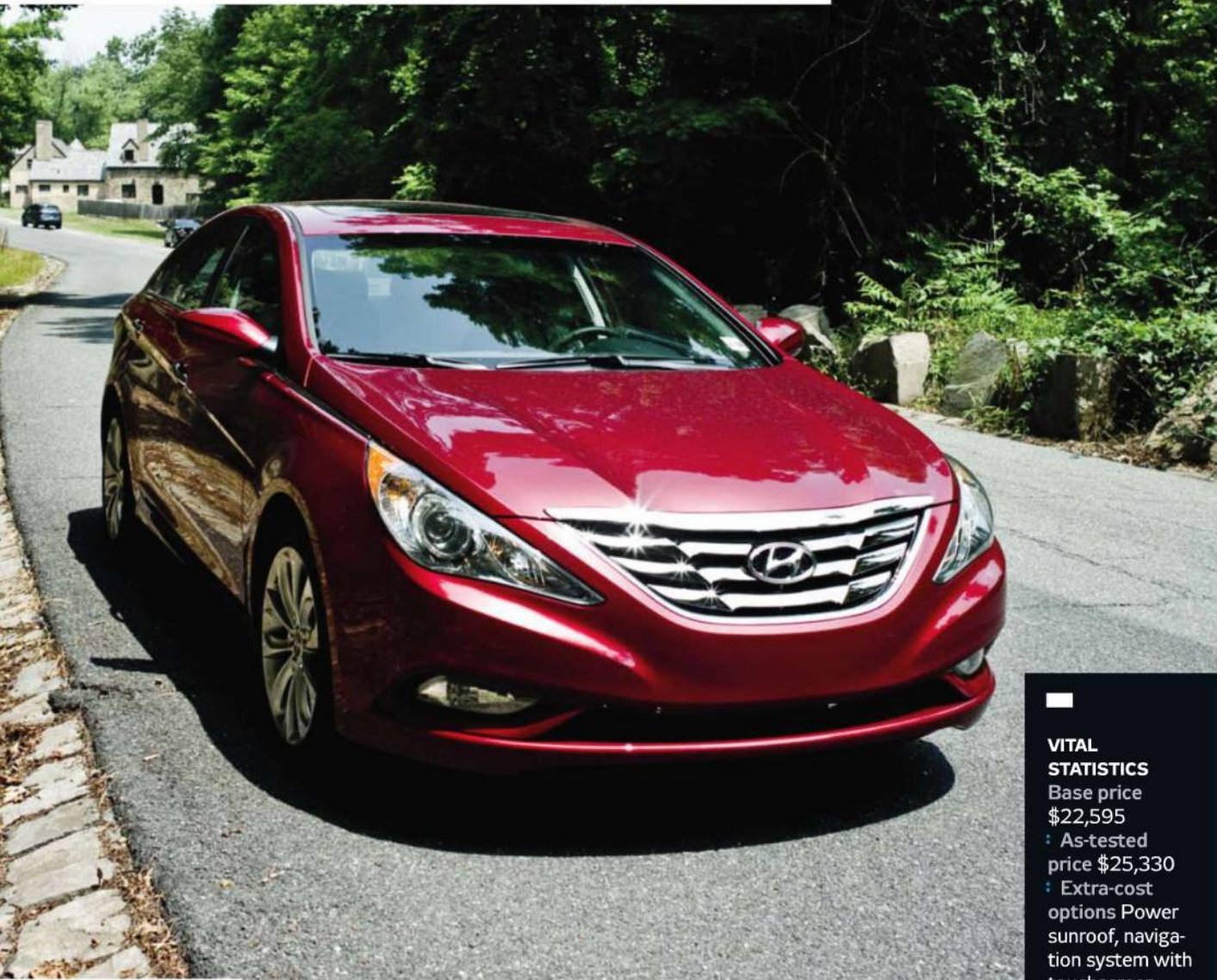


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Hyundai Sonata SE

FIRST report

What a difference a century makes.

Over 100 years ago, the Blitzen Benz, a German race car, pushed the land speed record past 140 mph with a 21.5-liter engine that made 200 hp. Today, the Hyundai Sonata SE, an affordable midsize, five-passenger sedan, comes with a 2.4-liter engine that makes 200 hp (two more ponies than the base GLS and top-level Limited model, thanks to dual exhausts). The SE also sports 18-inch wheels, along with a six-speed paddle-

shift automatic and tighter tuning for the front struts and rear multilink suspension. Freshly redesigned with a curvaceous exterior, the new Sonata resembles a Mercedes-Benz CLS, which prompted a tollbooth attendant to gush, "Nice car," and random New Yorkers to give us the thumbs up (which beats the usual Bronx salute). So, it's obviously a looker. Now, if those all-terrain Hankook tires would just top 130 mph, we'd give the ol' Benz a run for its money. — G.E. ANDERSON

VITAL

STATISTICS

Base price

\$22,595

• As-tested price \$25,330

• Extra-cost options Power sunroof, navigation system with touchscreen, satellite radio, carpeted floor mats, iPod cable

• Drivetrain 2.4-liter four-cylinder with direct injection, 6A, FWD • Engine performance 200 hp, 186 lb-ft of torque • EPA fuel economy 22 city/35 highway



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PM LONG-TERM TEST CARS


+ BMW X5 xDrive35d SECOND report

The X5 has rapidly become the most requested vehicle in the PM fleet. Staffers appreciate the spacious, comfortable, luxurious interior and sporty driving qualities (at least on smooth roads). Rough urban pavement is not the X5's friend, though for off-roading on groomed trails it exhibited a modicum of capability. Still, the

X5's AWD isn't optimized for slinging mud; it's meant for navigating (and remaining on) well-paved roads, quickly, efficiently and smoothly. One pump jockey thought we were kidding when we pulled the X5 into the diesel island, fooled by the relatively quiet idle. The engine pulls strongly from a stop and doesn't run out of

breath at higher rpm like many diesels. The X5 does bog slightly if you ask it to accelerate for a passing maneuver. The fix is to toggle the steering-wheel-mounted paddle shifter down a gear, which makes the passing exposure as blissfully brief as for any gasoline-powered SUV in its class. —MIKE ALLEN

DRIVERS NOTEBOOK

- A full tank of diesel and miserly mileage will propel this baby a good 500 miles, more than a week's worth of commuting.
- When you ask the navi to find nearby diesel, it can't distinguish between land-based stations and the local marina—and the X5 won't float over to the pumps.

DATA SO FAR

As tested : \$61,025
 Previous reports : See 08/10
 Miles driven : 8181
 Miles since last report : 7061
 Fuel economy : Average—24.9 mpg
 Worst—18.9 mpg
 Best—30.9 mpg
 Maintenance/repair : \$0

The car had its faults. Honda's Prius challenger putt-putted its way up hills in Tennessee's Great Smoky Mountains and New Hampshire's Whites. It was hard to see out the back, some interior materials felt cheap, and the smallish fuel tank (10.6 gallons) was a bit frustrating—in a fuel-sipper like this, you want to smugly motor past the SUVs at the pump, not get in line behind them. But the Insight grew on us. It steered well and felt snappy, not unlike its hip brother, the Fit. We could cram a surprising number of duffels into the back. The controls and data readouts were clear and useful. And then there was the stellar fuel economy: It's fun to surpass 45 mpg while giving up so little in return. After 19,000 miles—and about 400 gallons—the Insight earned our respect. —JERRY BEILINSON


+ Honda Insight EX Navi FINAL report
DRIVERS NOTEBOOK

- It was a hot summer, which highlighted the fact that the Insight's Econ mode depresses

the performance of the a/c. Tapping a button turns Econ off—but that hurts fuel economy.

- Great mileage, but would it kill Honda to

install a 12-gallon fuel tank and cover more road between stops?

DATA SO FAR

As tested : \$23,800

Previous reports : See 03/10, 06/10, 08/10
 Miles driven: 19,532
 Miles since last report : 7072
 Fuel economy :

Average—42.6 mpg
 Worst—33.8 mpg
 Best—54.6 mpg
 Maintenance/repair since last report : \$0
 Overall : \$758.71

URGENT MESSAGE

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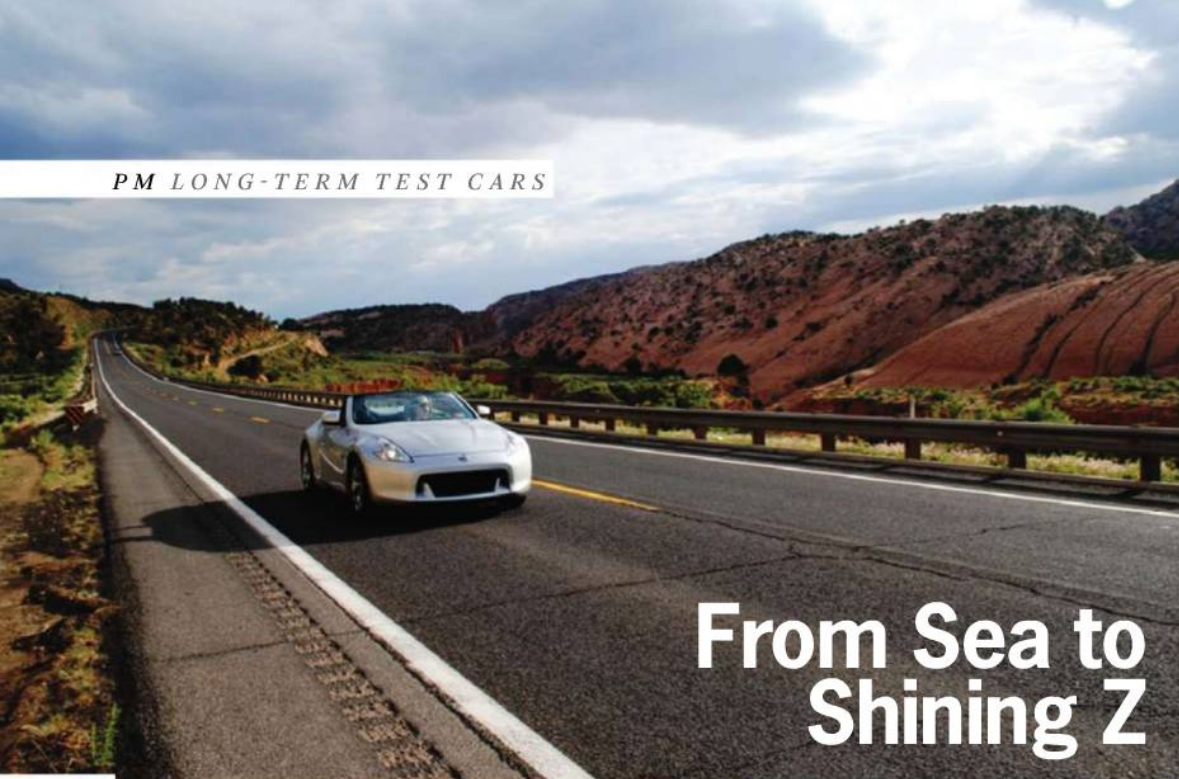
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From Sea to Shining Z

Nissan 370Z Roadster **THIRD report**

DRIVERS NOTEBOOK

- Can a roadster really be comfortable on a 3000-mile drive? Surprisingly, yes.
- The rev-matching seven-speed auto was made for mountain driving.
- The enclosed trunk makes the Z Roadster quieter than the coupe, despite ragtop noise.

DATA SO FAR

As tested :
\$44,405
Previous reports :
See 06/10,
08/10
Miles driven :
12,774
Miles since last
report : 7057
Fuel economy :
Average—
21.4 mpg
Worst—13.5 mpg
Best—27.5 mpg
Maintenance/
repair : \$35.50



Some tasks you just can't delegate.

Our 370Z long-term had spent six months on the West Coast, and it was high time we brought it to our home office in New York. A cross-country road trip was the only solution. I selflessly took on the job, and my son Benji, freshly graduated from college, volunteered as co-pilot.

DAY ONE

Our two small duffels practically fill the 4.2-cubic-foot trunk. And every cabin nook is stuffed with gadgets—a 3G iPad, a Mac laptop, a Nikon DSLR and, crucially, a Valentine radar detector. We crawl out of Santa Monica in afternoon traffic, but soon enough we turn off I-5 and roll north into the high desert. Darkness finds us flying past Edwards Air Force Base.

DAY TWO

Rolling east out of Barstow, we're hitting the towns in the song "Route 66" in reverse. Just past Kingman, Ariz.,



we leave I-40, put the top down and let the Z romp on the longest intact stretch of old 66. By late afternoon we're approaching Four Corners—big sky, empty roads. This is what we came for.

DAY THREE

An invigorating morning takes us from Cortez, Colo., to Telluride, the prettiest town in the Rockies. We rest for a day, mountain-biking the local trails and catching up with an old buddy.

DAY FOUR

Our route diagonals northeast through the heart of the Rockies. We use all 332 hp over the mountain passes and

give the paddle shifters a workout on the sweeping descents.

DAY FIVE

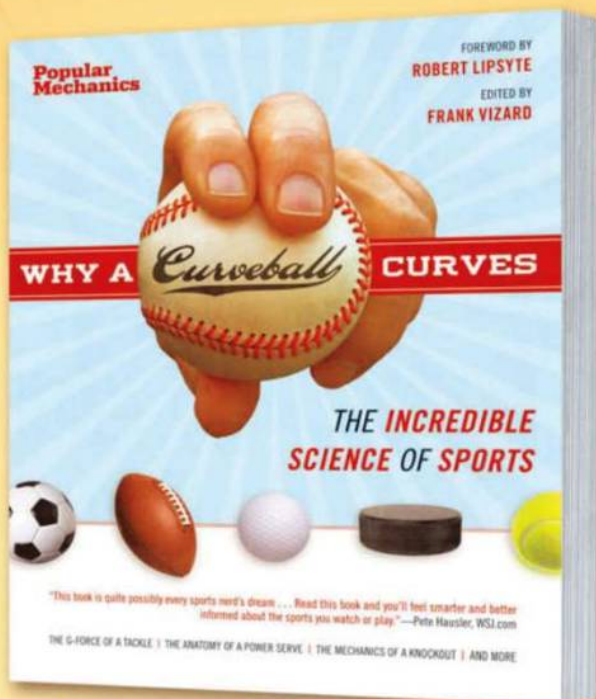
I-80 runs ruler-straight across Nebraska—a direct shot home. You'd think we'd be yearning for a bigger car by now, but the Z is remarkably livable. It's delivering 25 mpg, and our favorite iPad app—the speed-trap locator Trapster—keeps us out of trouble.

DAY SIX

It's a long day from Michigan to my driveway. But give me one good night's sleep and I would happily turn around and do it all again. —JIM MEIGS



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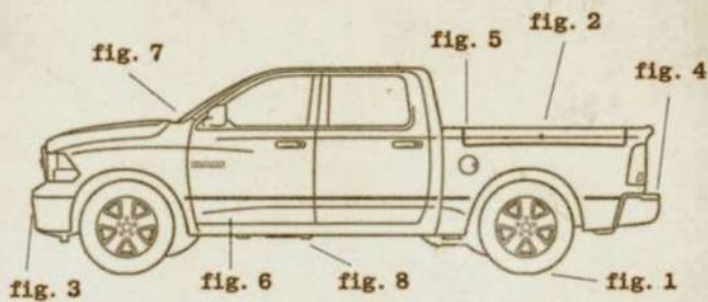
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China's Deadliest Game

ANY CHINESE MOVE TO TAKE OVER TAIWAN
WOULD TRIGGER A CONFRONTATION WITH THE
U.S. NAVY AND AIR FORCE. IS THE U.S.
PREPARED TO COUNTER THIS GROWING THREAT?

August 9, 2015

0400 hours

THE WAR FOR TAIWAN STARTS IN THE EARLY MORNING. There are no naval bombardments or waves of bombers: That's how wars in the Pacific were fought 70 years ago. Instead, 1200 cruise and ballistic missiles rise from heavy vehicles on the Chinese mainland.

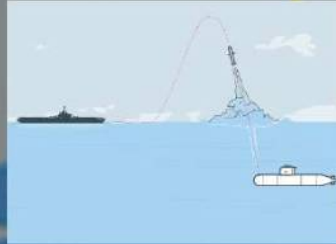
Taiwan's modest missile defense network—a scattered deployment of I-Hawk and Patriot interceptors—slams into dozens of incoming warheads. It's a futile gesture. The mass raid overwhelms the defenses as hundreds of Chinese warheads blast the island's military bases and airports. Taiwan's air force is grounded, and if China maintains air superiority over the Taiwan Strait, it can launch an invasion. Taiwanese troops mobilize in downtown Taipei and take up positions on the beaches facing China, just 100 miles to the west. But

• BATTLE OF TAIWAN

In this hypothetical scenario based on Chinese defense plans and the Pentagon's response, the invasion of Taiwan would start with a missile barrage aimed at the island. The White House would order the USS *Nimitz* to intervene; ballistic missiles would soon rain on the U.S. Kadena Air Base at Okinawa, Japan, grounding planes that could protect the aircraft carrier. China's next step: Destroy the *Nimitz*.



• AUGUST 9, 2015 / 1230 HOURS / FIRST ATTACK



Quiet Kilo-class submarines evade the sonar of the *Nimitz*'s escorts and hammer the aircraft carrier with Russian-made hypersonic missiles. These move so fast—closing in at Mach 3—that the ship's defenses cannot shoot them down.

CHINA

JAPAN

OKINAWA

USS *NIMITZ*

TAIWAN

• AUGUST 9, 2015 / 1921 HOURS / SECOND ATTACK



Fighters from the *Nimitz* scramble to meet Chinese airplanes, not knowing that the incoming strike group is made up of older warplanes converted to fly unmanned. Modern, better-armed Chinese planes then attack from another direction.



• AUGUST 9, 2015 / 2035 HOURS / THIRD ATTACK



DEADLY
MISSILE
DEBUT

The crippling blow is delivered by antiship ballistic missiles, launched from the mainland. They carry warheads maneuverable enough to target a moving vessel. One warhead slams through the *Nimitz*'s deck from directly above, disabling the carrier.





they know what the world knows: This is no longer Taiwan's fight. This is a battle between an old superpower and a new one. Ever since 1949, when Nationalist forces retreated to Taiwan following the Communist victory in the Chinese Civil War, Beijing has regarded the island as a renegade province of the People's Republic. Now, in 2015, only the United States can offer Taiwan protection from China's warplanes and invasion fleet.

The nearest aircraft carrier is the USS *Nimitz*, which had just left the Japanese port of Yokosuka on Tokyo Bay when the missiles landed on Taiwan. Although Beijing has promised to attack anyone who interferes with this "internal security operation," the U.S. president orders the *Nimitz* and its escorts to the Taiwan Strait. The *Nimitz* battle group needs at least two days for the carrier to reach the strait, more than 1300 miles southwest. The closest other carrier group, near Pearl Harbor, is six days out.

Until the *Nimitz* arrives, it's up to Kadena Air Base in Okinawa, 400 miles northeast of Taiwan, to defend the island. By 0515 hours, Air Force pilots are taking off in 40 F-15E fighters to conduct combat air patrols over the island. Half of them are airborne when Kadena comes under attack. First, error messages begin popping up on computer screens. Modern air defense systems share sensor information and targeting data to better coordinate their actions, but this connection is going to become a liability. An army of hackers operating throughout China swarms the base's networks, tying up communications with gibberish and cluttering the digital screens of radar operators with phony and conflicting data.

Next, early-warning satellites detect the infrared bloom of 25 ballistic missiles launched from the Chinese mainland. Five detonate in orbit, shredding American communication and imaging satellites. While not a technical first—both the U.S. and China have knocked down satellites—it's the first outbreak of a hot war in space, and it partially blinds U.S. forces.

The 20 remaining missiles re-enter the atmosphere over Okinawa. Kadena's Patriot batteries fire missiles in response, but they are off-network and in disarray—10 missiles are struck by multiple interceptors, but an equal number slip through the defensive screen and hit Kadena. Some of the GPS-guided warheads contain bomblets that crater the base's two runways. Others airburst over the base, devastating barracks, radar arrays and hangars. Kadena is far from destroyed, but until its runways can be repaired, it is out of the fight. The F-15s on the way to Taiwan must bank for Guam, 1300 miles southeast—they have the range to reach the base there, but only Kadena is close enough to stage efficient combat patrols. Also, F-22 stealth fighters based at Hickam Air Force Base, Hawaii, now cannot land on the base's shattered runways and reinforce the F-15s. With Kadena's satellites gone, the *Nimitz* and its flotilla of eight escorts,

IF MISSILE DEFENSE TOOLS DO NOT PERFORM AS ADVERTISED, U.S. AIRCRAFT CARRIERS COULD BE PUSHED SO FAR FROM A FIGHT THAT THEY'D BECOME IRRELEVANT.

including Aegis-guided missile destroyers and a pair of submarines, are steaming toward an enemy possessing one of the world's largest submarine fleets and an arsenal of land-, air- and sea-launched antiship missiles.

About 8 hours after the mass raid on Taiwan, klaxons start blaring aboard the *Nimitz* and her escorts. There are more missiles in the air, this time headed straight for the carrier group. The Taiwan Strait is still more than 1000 miles away, but the war has come to the *Nimitz*. Skimming the surface of the Pacific are four supersonic missiles flying faster than their own roar.

CHANCES ARE THAT WAR BETWEEN CHINA AND the United States will not happen in 2015, or at any other time. Under normal circumstances, a war for Taiwan would simply be too costly for either side to wage, especially given the chance of nuclear escalation. But circumstances are not always normal.

"I get criticized often for saying this, but I think Beijing is capable of acting irrationally when it comes to Taiwan," says retired Rear Adm. Eric McVadon, who served as a naval attaché in Beijing and is currently senior adviser of Asia-Pacific studies at the Institute for Foreign Policy Analysis in Cambridge, Mass. "They are obsessed with Taiwan. On some given day, it's entirely possible for people to be standing around a table in the Politburo in Beijing, and someone gets the ball rolling. And when it stops, we're at war."

The deciding factor could be anything from domestic unrest in China's increasingly rebellious rural provinces to a spike in aggressive, vocal Taiwanese nationalism. However, like many Pentagon war games, this notional conflict is not concerned with potential political triggers, but instead with evaluating China's raw military capabilities. The scenario is based on analyses by civilian think tanks including RAND Corp., Chinese defense papers and interviews with senior Pentagon officials.

The chance of war may be remote, but the Chinese strategy to deny American access to battlegrounds near China's coasts—and the hardware to pull it off—certainly



The USS *Nimitz* is not just an American symbol. The air power delivered by an aircraft carrier, and its crew of nearly 6000, can sway the tide of a battle—or prevent one from occurring. That's why potential foes like China are investing in weapons that could target carriers and nullify U.S. global influence.



exists. Since the Gulf War, the Chinese military has shifted from academic analysis of how to defeat U.S. aircraft carriers in the East China and South China seas to buying and building the weapons to make the plan a strategic reality. This is not a Cold War-era buildup, aimed at waging or deterring an apocalyptic last stand. This is a force engineered to win a limited local war—for example, keeping the United States away long enough to win Taiwan.

China's economic boom has allowed its military to rapidly expand its inventory of cruise missiles, aimed at

Taiwan, and multistage ballistic missiles with enough range to hit much of Asia. The People's Liberation Army has also bought submarines—including at least 12 whisper-quiet diesel-electric models from Russia—and is developing a large fleet of warplanes.

But China's most dangerous new weapon could be an antiship ballistic missile (ASBM), specifically designed to target a moving aircraft carrier. The United States has 22 carriers. To win a future conflict, China would not have to destroy every one of them, just the pair that would

WEAPONS BEHIND THE PLAN

China has spent billions developing and buying arms to sink American aircraft carriers. Here's how the U.S. can fight back.



CHINA ATTACKS WITH:

KILO-CLASS DIESEL-ELECTRIC SUBMARINE



China purchased at least a dozen small subs that are practically invisible to standard sonar. The PLA outfitted them with supersonic Sizzler antiship cruise missiles that can outrun many shipboard defenses.
Status: Deployed since the 1990s.

UNMANNED AERIAL VEHICLE (UAV)

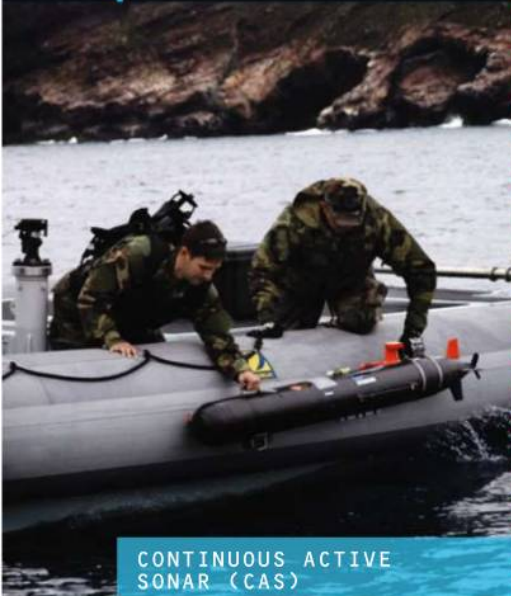


China's inventory of UAVs ranges from converted warplanes used for target practice to experimental high-altitude surveillance drones. A swarm of robots can be a cheap way to help overwhelm and deplete air defense systems.
Status: The Chinese military already uses foreign-made UAVs; development of domestic UAVs is well under way.

DF-21C MEDIUM-RANGE BALLISTIC MISSILE

The DongFeng-21C is part of the new generation of precision ballistic missiles, capable of hitting targets throughout much of Japan. It can carry multiple warheads, and its GPS-based guidance makes the DF-21C as accurate as a cruise missile.
Status: Believed to have been deployed since 2004.

AMERICA COUNTERS WITH:



CONTINUOUS ACTIVE SONAR (CAS)

A steady beat of acoustic pulses forms a single high-resolution image, defeating sound-absorbing materials found on Kilo-class subs.

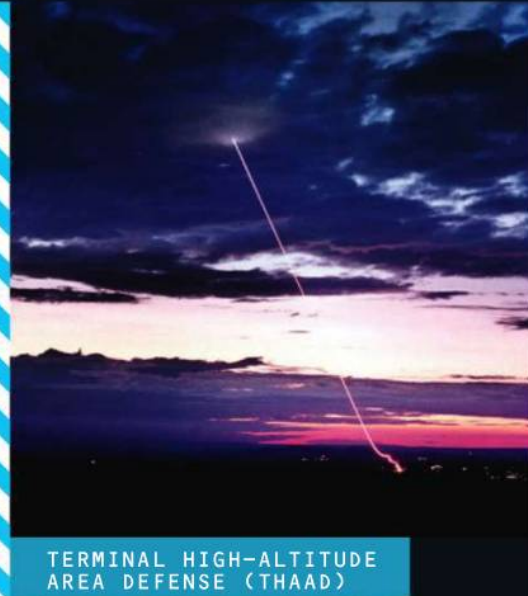
Status: The Navy has tested CAS towed from surface ships; vendors are installing CAS in underwater unmanned vehicles.



FREE ELECTRON LASER (FEL)

This ship-mounted, 100-kw laser would specialize in hitting missiles and small aircraft. Laser systems avoid dependency on a stock of defensive missiles, and can quickly adjust fire to handle massed aerial attacks. The DDG-1000 destroyer, to be fielded in 2015, may carry the system.

Status: FEL remains in early development; Boeing's Avenger in 2009 became the first laser system to shoot down a UAV (above).



TERMINAL HIGH-ALTITUDE AREA DEFENSE (THAAD)

This vehicle-towed battery of 24 ground-based interceptors can target ballistic missiles in their final, or terminal, phase of flight.

Status: Limited deployment in Hawaii and Texas in 2008; the U.S. Missile Defense Agency planned to deploy THAAD in March, but quality-control problems have delayed the first deliveries.

DF-21D ANTISHIP BALLISTIC MISSILE (ASBM)

If Chinese engineers can perfect it, the ASBM will be the first of its kind: a ballistic missile with sensors that enable it to hunt down an aircraft carrier at sea. **Status:** In development; Pentagon officials warn that demonstration flights of early prototypes could come soon—perhaps within a year.



NETWORK-CENTRIC AIRBORNE DEFENSE ELEMENT (NCADE)

The U.S. has no current defense against an ASBM. One possible foil is NCADE, an aircraft-launched weapon designed to spot and ram a ballistic missile before it reaches space. **Status:** Could be deployed by 2014. In late 2007 Raytheon successfully tested NCADE missiles fired from two F-16s over the White Sands Missile Range in New Mexico.

be available to respond to a fight off China's coast.

Senior Pentagon leaders are becoming increasingly concerned about the Chinese arsenal. Adm. Robert Willard, head of the Navy's Pacific Command, told Congress in March that "the PLA's continued military advancements sustain a trend of shifting the cross-strait military balance in Beijing's favor." In June, in a speech at the Asia Society in Washington, D.C., Adm. Mike Mullen, chairman of the Joint Chiefs of Staff, added that he has "moved from being curious to being genuinely concerned" about the buildup.

The man who would face the Chinese in battle, Adm. Patrick Walsh, the current commander of the U.S. Navy's Pacific Fleet, sees preparation as a way to avoid a future fight. "When we look at these sorts of developments, such as the ASBM, they are technological developments that we respect, but do not necessarily fear," Walsh says. "The key element in any sort of deterrent strategy is to make it clear to those who would use a given piece of technology that we have the means to counter it, and to maintain a technological edge."

Right now the Chinese seem to have taken the lead in this new arms race. When RAND released a report in 2000 describing the potential outcome of a Sino-American conflict over Taiwan, the United States won the war handily. Nine years later, the nonpartisan think tank revised its analysis, accounting for Beijing's updated air force, its focus on cyber warfare and its ability to use ballistic missiles to take out American satellites. RAND's new conclusion: The United States would ultimately lose an air war, and an overall conflict would be more difficult and costly than many had imagined.

August 9, 2015

1230 hours

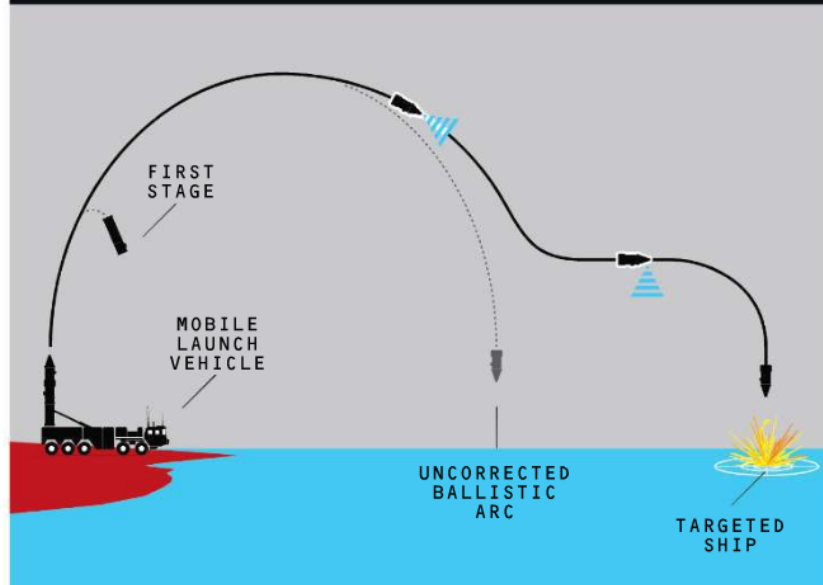
THE KILO-CLASS SUBMARINES ARE WAITING. Like any patient hunter, that's what they do best. Smaller and slower than their nuclear-powered counterparts, the 230-foot boats are fitted with diesel-electric engines and sound-absorbing tiles that make them virtually invisible to active and passive sonar. They have chosen the spot for an ambush wisely, lurking near rises in the seafloor that clutter sonar returns, and the *Nimitz*'s escorts don't detect the Kilos.

The Chinese subs rise to launch depth and fire two missiles each from their torpedo tubes. The Russian-made weapons burst out of the water and tear directly at the carrier group.

Alarms are wailing on every ship as sailors dash to battle stations, but the *Nimitz* is the sole target of these Russian-built antiship cruise missiles. They are called



CHINA'S CARRIER KILLER



The most alarming weapon China is developing to deny the U.S. Navy access to the East and South China seas is the antiship ballistic missile—the first such missile able to change course to hit a moving aircraft carrier. Mounted on a mobile launch vehicle, an ASBM would rise in two stages, reach space and then use fins to maneuver at hypersonic speeds on its way back down. The warhead then glides along a level path to permit synthetic aperture radar, which processes multiple radar pulses to form a single picture to target the carrier. Finally, the warhead's infrared seeker locates a carrier's signature and closes in for the kill.

SS-N-27B Sizzlers. When the missiles come within 10 nautical miles of the carrier, a rocket-propelled warhead separates from each and boosts into a darting, Mach 3 sprint, skimming along just 30 feet above the surface of the waves.

In the final moments, chaff launchers on the *Nimitz* release a volley of decoys, while a trio of robotic chain guns aboard the *Nimitz*—the last line of missile defense—automatically pivot toward the warheads and fire hundreds of 20-mm rounds per second. One Sizzler misses. Two more break apart under fire. The fourth detonates against the *Nimitz*, tearing a hole in its port side. More missiles arc across the sky as Aegis cruisers shoot antisub munitions into the ocean, tearing apart one Kilo. The other sub eventually will be hunted down by aircraft carrying sonar and torpedoes, but the damage is done.

On the *Nimitz*, there's no time to mourn the dead. The next attack will come soon. The crew assess the battle damage and begin repairs while the carrier presses on.

August 9, 2015

1921 hours

ON THE SOUTHEAST COAST OF China, more than 500 miles west of the *Nimitz*, an over-the-horizon radar array has picked up the carrier's position. Based on coordinates supplied by the now-sunk Kilos, the array seeks the carrier by banking radio waves off the atmosphere to peer beyond the earth's curvature. After the signals indicate the flotilla's rough location, the Chinese deploy a drone to confirm the radar fix. This 12-foot-long unmanned aerial vehicle (UAV) does its job before being blown apart by an anti-air missile fired by a destroyer. The *Nimitz* is swarmed within the hour.

A formation of fighters appears on the carrier's radar screens. Defensive missiles lift off from a picket line of escort vessels, and the *Nimitz* begins launching its own F/A-18s to meet the incoming aircraft, which appear to be more than a dozen outdated Jian-7s. With no satellite coverage, thanks to the antisat attack, the surprised escorts can only form a defensive ring around the carrier as the J-7s

unleash a volley of antiship cruise missiles.

The U.S. escorts fire at all inbound airplanes, not knowing that the Chinese have retrofitted these older warplanes to serve as unmanned decoys. The battle group cannot trust its computer networks, given the hacking attacks on Kadena, so they must pick targets independently. The defense crews double up on some incoming fighters, wasting their defensive missiles. Radar contacts are vanishing as airplanes and incoming air-launched cruise missiles are destroyed, but one missile gets through, ripping another fiery hole in the *Nimitz*.

By the time F/A-18 pilots radio that no one is parachuting from the downed J-7s, the main Chinese attack force of high-performance, manned J-10 and J-11 warplanes arrives from the east. The carrier group's F/A-18s move to intercept them. But the Chinese fighters aren't here to dogfight—they launch antiship cruise missiles at the carrier and disengage.

The Aegis cruisers fire a slew of defensive missiles;



F/A-18s fire anti-air missiles. The sky over the Pacific is a lattice of smoke trails, and through the call and response of sonic booms there is another explosion as the *Nimitz* takes its third cruise missile hit of the day.

There is no lull, no time to regroup—unharmful Missile Defense Agency satellites have detected another volley of ballistic missiles fired from China. These aren't projected to hit Taiwan, Okinawa, or any other land-based target. They are tracking toward the carrier group. These are ASBMs.

The Aegis cruisers respond, launching multistage SM-3 interceptors that rise like a cluster of suns. Once in space, they deploy kill vehicles, self-guided craft designed to ram ballistic missiles. Only one connects. Four ASBMs re-enter the atmosphere and perform a swooping, high-g maneuver that allows them to scan the ocean's surface for their moving target.

So the battle for the *Nimitz*, and for Taiwan, ends as it began, with missiles. At 2015 hours, two ASBMs dump harmlessly into the sea, victims of technical glitches. The other two dive into the carrier, shattering the superstructure and killing hundreds. The damage doesn't reach the two nuclear reactors, but two gaping holes in the flight deck, and the carnage in the hangars below, render the ship useless. The *Nimitz* must retreat. If this were an all-out war, the PLA would push one last time to sink the carrier. But China's goal was never to trigger an extended, costly, bloody contest of superpowers. The goal was to deny American access to Taiwan prior to an invasion.

The following morning, Chinese troop transports cross the strait and secure the island without firing a shot. A brutal ground war was never part of the plan. Beijing calculated that without American assistance, Taipei would surrender. It also predicted an endless loop of video footage of the crippled *Nimitz* returning to port. There is more than one way to win a war.

THE U.S. MILITARY SHOCKED THE WORLD WHEN it unveiled the sophisticated weaponry used to defeat Iraq's military in 1991. Now potential adversaries have invested in tools similar to those that made the United States military so dominant during the Gulf War. "Since the end of the Cold War, we've been in the position to unleash substantial quantities of precision firepower on our adversaries, while suffering none of that type of attack," says RAND's David Shlapak, one of the authors of the think tank's original 2000 report on a war over Taiwan as well as the followup 2009 report. "That led us to a certain style of warfare—bases that are sanctuaries, lines of communication that are indestructible."

That technological edge led to overconfidence, and Cold War skill sets, such as submarine hunting, atrophied. At the same time, the Russians sold quiet diesel-



"THE UNITED STATES CONTINUES TO SELL ARMS TO TAIWAN, CAUSING SERIOUS HARM TO... PEACE AND STABILITY ACROSS THE TAIWAN STRAIT."

FROM "CHINA'S NATIONAL DEFENSE IN 2008" WHITE PAPER, HELD BY SENIOR COL. HU CHANGMING IN 2009



"OVER THE YEARS THERE HAS BEEN A BUILDUP OF MISSILES POINTED AT TAIWAN. LET CHINA ACCOUNT FOR THAT POSTURE."

ADM. PATRICK WALSH, 2010

electric Kilo submarines to countries like Iran and China. When the Navy placed Rear Adm. J.J. Waickwicz in charge of the Fleet Anti-Submarine Warfare Command in 2004, he determined it would take years to re-establish sub-hunting expertise. "There was a lack of training and really good equipment to manage the problem," says Waickwicz, now retired. "We have to be willing to put the funding into synthetic and simulation training."

When it comes to missiles, China may be surpassing the United States. Earlier this year, the Pentagon said China has "the most active land-based ballistic and cruise missile program in the world." And no one else has developed an ASBM. Despite billions of dollars in research and controlled tests, the results of a clash between sophisticated missiles and modern defense interceptors are unknown. If missile defense tools do not perform as advertised, carriers could be pushed so far from a fight that they'd become irrelevant, nullifying America's principal tool of power projection.

What can be done? Most war games end with a "hot wash," a kind of debriefing, where participants discuss what went right and what went completely wrong. They discuss what they would do differently if they could roll back the clock. And sometimes, they do just that—rewind and run through the fight all over again.

CONTINUED ON PAGE 129

BY MIKE ALLEN

FAST

PHOTO: JEFFREY ZEPPELIN 32 REGULAR 5.5/6PT TRACK 150

Garden-variety Porsche 928? Hardly. The pipe in the front bumper is not an air intake for the engine—it's the exhaust.

BACKWARDS

PM HELPS THE MYTHBUSTERS TACKLE A DECADES-OLD AUTOMOTIVE LEGEND: IS THE PORSCHE 928 MORE AERODYNAMIC GOING BACKWARDS?

PHOTOGRAPHS BY KAREN BALLARD

SMALL CREDIT ZEPPELIN 32 REGULAR 5.5/6PT TRACK 150

I

t's 8 am on a Monday morning. Instead of riding the elevator up to POPULAR MECHANICS's Manhattan office, I find myself in San Francisco, holding my welding helmet and keying in the entry code to one of several doors in a plain-Jane industrial park. A sign on the wall reads "M5 Industries," a surefire giveaway to fans of *MythBusters*. This is the TV show's home base, where I have an audacious mission: remove the body of a Porsche 928 and weld it back on—backwards. I have four days to complete this monumental build, and one to debug it, so Adam Savage and Jamie Hyneman can test the inverted car the following Monday.

START



THREE, TWO, ONE—LIFT!

Turning a Porsche 928's body around in order to test the myth that the vehicle is more aerodynamic backwards started with two days of cutting the body free. Then Jamie, Adam and the *MythBusters* crew helped us lift it off. We needed lots of hands to distribute the weight and keep the flimsy body from distorting—the body of the 928 wasn't designed to stand free of the chassis.



MIKE ALLEN
PM SENIOR EDITOR, AUTOMOTIVE



ADAM SAVAGE + JAMIE HYNEMAN
THE MYTHBUSTERS

KEEP IT STRAIGHT

I taped the doors and rear hatch shut (above, left) to give the body as much structural integrity as possible during its delicate removal. The MythBusters,

who once made a boat of duct tape, heartily approved. Above, right: Adam (left) inspected the Porsche's insect-like intake system, which, thank-

fully, didn't require reworking. Behind them were shelves stocked with 600 crates of supplies. Sadly, none contained a "Porsche reversal" kit.

The two hosts greet me as I open the door. Before expressing pleasantries, Adam says, with his typical enthusiasm, "Dude, you brought your own welding helmet! We got the right guy."

Why me, you're asking? A week or so earlier, I had picked up my ringing phone and, surprise—Jamie was on the line. Okay, Jamie and Adam often write for PM and have visited the office more

than once. Last year a bunch of us from the magazine spent a few very hot days dirt-biking through Death Valley with Jamie (Sept. '09)—but since he lives on the other coast, we don't chat every day. Off-camera, Jamie is just like he is portrayed on the show—all business—and he got right to it. "Mike," he said, "we want to test the myth that a 928 is more aerodynamic going backwards, and to

do that I need to figure out how to measure the aerodynamic efficiency of a vehicle." I was intrigued. That myth has been around since the sexy V8-powered coupe debuted in 1978. "No problem," I said. "Just park it in a wind tunnel and read the numbers off the screen." Jamie, however, had a more ambitious plan, one that fit the MythBusters' paradigm of an extreme build and a hands-on test.



NOSE AMPUTATION

The front end of the engine bay had to be shortened so the stubby rear cargo area could fit. That meant the bumper supports, fans, a/c condenser and headlight

frames all had to go. We eventually had to add nearly 400 pounds of ballast to equal the stock car's weight. To ensure the front and rear ride heights were retained, we used wheel scales to set the front-to-rear weight bias close to the original 50:50 proportion.



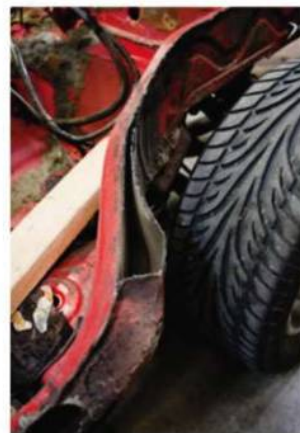
IT'S NOT REALLY A CONVERTIBLE

The most complicated cuts were at the bottom of the A-pillar and firewall confluence, since the area is so hard to access and contains sev-

eral sheet-metal panels. We welded in a steel bar to support the dash. The computer and ignition boxes were removed so the MIG welders

wouldn't fry the boxes' delicate insides. To preserve structural integrity, we cut the rocker (at the bottom of the photo above) in half, along its

length, instead of cutting it out. Removing the body left several gaping holes (above, right) in the structure that we eventually welded shut.



He wanted to actually build a backward 928 and measure its fuel consumption, which would reflect the amount of power used to push it through the air. If the car used less fuel going backwards, then that configuration would be more aerodynamic. I thought that approach was too complicated and the results too difficult to repeat. But before we came to any conclusion, Jamie said, "You sound

like you know a lot about this. Why don't you come help us?" Me and my big mouth. I immediately booked a flight.

From my racing days I know a lot about the nitty-gritty architecture of the 928's underpinnings. Removing the body in one piece so that it could be reattached without twisting up like a Pringle would be a real challenge. In fact, no one's ever done it. The 928 is a

unit-body car made from dozens of thin sheet-metal stampings, none thicker than a dime. The pieces are welded together, and they rely on one another for strength. It's not like the old days, when cars had separate bodies that could be unbolted from a distinct frame.

For anyone mechanically inclined, M5 is like a giant playground. Jamie and I head straight to the shop. Television's



GOING TOGETHER

Above: It was Thursday, four days into the build and just three days until testing. We needed every minute to fiddle, trim and modify the chassis to accept the backward body. The rocker panels mated up directly, but in many other places we had to MIG-weld 20-gauge-steel scab patches to bridge gaps.



"IT'S ALIVE"

M5's forklift proved to be a perfect hoist for countless test fittings. On day six there was a resounding cheer when we finally got

the body to fit. With the hardest part over, we hooked the engine to a 2-gallon fuel cell and turned the key. Nope—no immediate joy. We

soon deduced that the car's burglar alarm wasn't happy with some of the cuts we had made to the wiring harness. Grounding a couple

of wires that used to go into the door's wiring fixed that, and the car fired up. A few more loose ends later, we were ready to test—just in time.

wide-angle lenses make the work space appear a lot larger than it actually is. Cleaner, too. Beneath the glare of a dead mechanical shark hanging on the wall, I survey all the assembled gear. A penumbra of toolboxes, plasma cutters, air tools and metal-inert gas welders surrounds a nervous-looking 1984 Porsche 928 S that's about to be disem-boweled. Jamie introduces me to M5

fabricator Don Best, and the three of us discuss tactics.

Jamie wants to cut through the car's floor pan, between the seats and the rocker panels, a method I'm afraid will make the chassis sag between the wheels like a banana. I want to separate the rocker panel into inner and outer halves, to keep the car's structure intact. Jamie ultimately defers to my superior

knowledge of Teutonic automotive architecture: We'll do it my way.

The next two days are filled with the screech of cutoff wheels and Sawzalls, the hiss of the plasma cutter and the crackle of the occasional small fire as Don and I remove the interior, dash-board and extra wiring. Every couple of hours, the camera crew shows up, which usually burns about an hour as we pose



ADAM: "THIS IS SO WRONG!"

THE TEST

Now that we had our backward Porsche, the producers secured an unmodified silver 928, and we set out for the MythBusters' favorite test site, the runways of the decommissioned Navy base in Alameda, just across San Francisco Bay. The plan was to run the cars side by side up to 100 mph, shift into neutral and coast to the end of the runway. The car with the lower drag coefficient (Cd) would take longer to slow down, pulling ahead of the high-drag car and finally putting an end to this automotive mystery. Why 100 mph? Because aerodynamic drag climbs with the square of velocity,

so the higher the speed, the bigger the difference, if any. We also pointed the cars into a 15-mph headwind—higher airspeed equals more drag—and added 30 pounds to our bizarre Porsche so the two cars weighed the same. Adam drew the short straw, so he drove our project car and endured the heat that poured from the radiator onto his balaclava'd head. Jamie piloted the unmodified Porsche. My job wasn't over: As the guys blasted down the runway, I manned the radios.



MYTH TESTED →

For results, watch the "Reverse Engineering" segment on *MythBusters*, 9 pm ET, Nov. 17, on the Discovery Channel.

and redo what we just finished fabricating. Occasionally we also have to desist from noisemaking while the crew tapes a vignette for a different segment. Flipping a car around tends to make a racket: Quiet denotes lost progress.

Don and I become good friends, which is easy when you spend 12 hours a day for a week underneath the same car, covered in slag and grinding dust. I'm

not the least bit surprised when we're still hard at it the following Sunday.

The next morning at the test site, I wriggle through our project car's window and blast down the runway. True to its breeding, the 928 feels rock-solid at 140 mph, meaning we've properly welded it back together and the chassis still has enough rigidity to keep the suspension stable. Hot air off the radiator blasts my

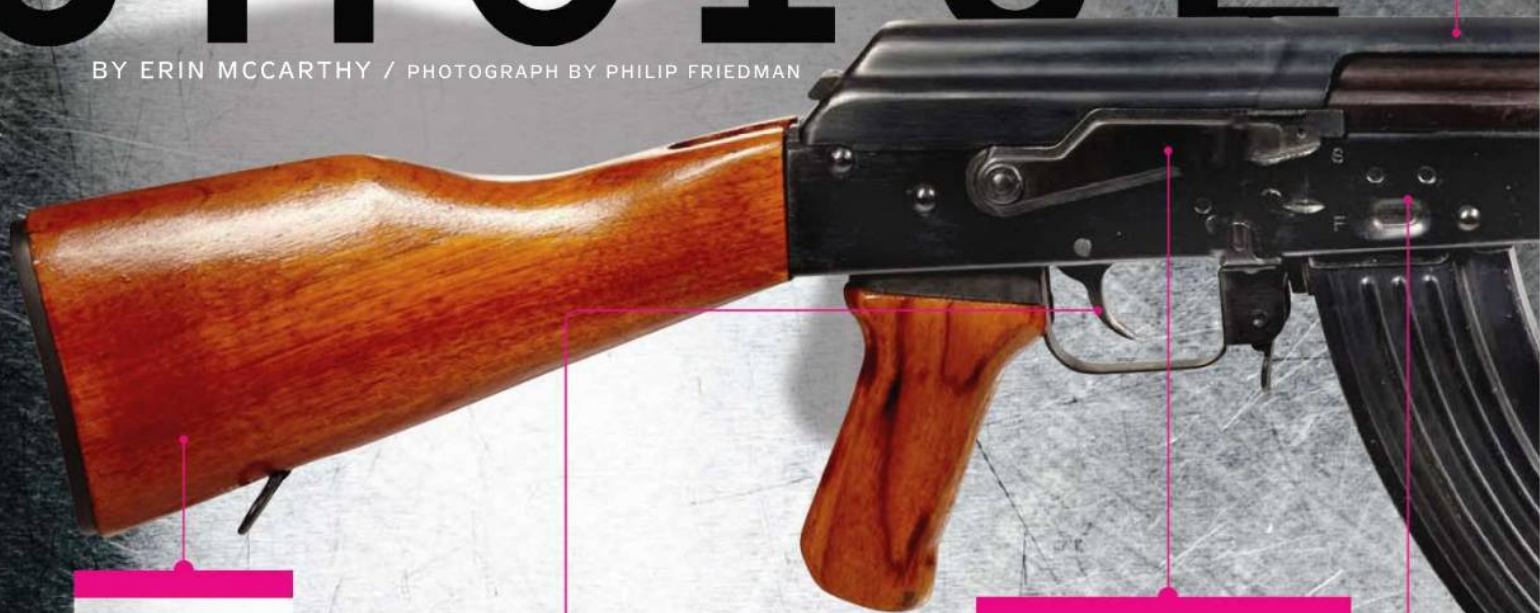
face and dirt vacuumed from the surface fogs the cockpit. Before the next run I empty three cans of construction foam into the leftover voids, but this doesn't keep the dirt out, and soon a thick layer of dust and debris carpets the floor.

Adam is standing nearby, obviously excited to try our new toy. "Can I drive it?" he asks. My primary mission accomplished, I hand over the keys. **PM**

WEAPON OF CHOICE

- **AT THE DAWN OF THE COLD WAR**, former Soviet soldier Mikhail Kalashnikov, 26, led a team in the design of a lightweight assault rifle, the Avtomat Kalashnikova 1947. Now, 65 years later, some 100 million AK-47s have been produced—10 times the number of U.S. Army M16s. The original weighed roughly 10 pounds and married the best features of a submachine gun and a long-range rifle. “The AK-47 is often said to be poorly made, but many of its features were well-matched to the conditions of war,” says C.J. Chivers, *The New York Times* war correspondent and author of *The Gun*, a history of the AK-47. The rifle is effective, if unoriginal. “Think Mr. Potato Head. This gun is a bunch of pre-existing systems combined into a new whole,” he says. A revised AK-47, the AKM, entered production in 1959; the most prevalent AK, its knockoffs are manufactured all over the world (the gun below has Chinese origins). Chivers gives a guided tour.
- Avtomat Kalashnikova Modernized / 1959 / Length: 35 inches / Weight: 8 pounds

BY ERIN MCCARTHY / PHOTOGRAPH BY PHILIP FRIEDMAN



1 | STOCK

Designers replaced the AK-47's solid-wood stock and handgrip with less expensive and sturdier plywood in the AKM. (This model, however, has solid wood.) Guns with folding metal stocks, better for tight spaces, were made for airborne and armored-vehicle troops.

2 | TRIGGER The AK-47's trigger group borrows from the designs of American infantry rifle maker John C. Garand, who created the M1, and German gun maker Hugo Schmeisser, a Soviet prisoner at the time the original AK-47 was devised.

3 | RECEIVER The rifle's receiver anchors the integrated gas piston and the trigger group. In the 1940s, workers created the receiver by machining a 4-pound block of steel into the 1.5-pound component. “It took 150 different machine motions to make it, so there was a huge manpower loss there,” Chivers says. The AKM's stamped sheet-metal receiver simplified production and reduced the rifle's weight to about 8 pounds. The integrated gas piston and bolt carrier's parts were designed to fit loosely in the receiver, making the mechanism less susceptible to the effects of carbon buildup, rust and dirt—and thus less prone to jamming. Kalashnikov claimed credit for these ideas, but they were actually adopted from other Soviet designs of the time, including Alexey Sudayev's AS-44. After Sudayev died in 1946, his “loose fit” concept was used by other designers.

4 | SELECTOR SWITCH

The AKM has three modes of firing regulated by the selector switch: safe, when it cannot fire; semiautomatic, for the squeezing off of single shots; and automatic, to spit lead at a rate of 700 rounds per minute.

5 | GAS PISTON The AK-47's combined bolt carrier and gas piston design—taken from a competitor—gives the gun's operating system more energy. As each round is fired, gas rushes into a chamber via a port in the top of the barrel, driving back a piston that withdraws the bolt from the chamber and ejects the spent cartridge. The spring-loaded magazine forces the next cartridge into place; a return spring thrusts the piston and bolt assembly forward, chambering the cartridge and preparing the rifle to fire again. The system's stroke is 50 percent longer than necessary, so the weapon often functions even when impeded by fouling, foreign substances or lack of lubrication.

6 | MAGAZINE The banana-shaped cartridge holder is a borrowed design, in keeping with the AK-47's cobbled-together makeup. "The curved, detachable magazine had been used on weapons of Soviet provenance, including the AS-44, an early Red Army attempt to knock off the [German] Sturmgewehr," Chivers says. But the Soviet Union found that this design was less likely to jam, in part because its shape fit the 7.62 x 39-mm round, which was tapered and stubby—unlike many types of earlier ammo, which were longer and less tapered.

7 | PROTECTIVE COATING Like its intentionally loose design, the rifle's rust-resistant phosphate coating increased its reliability. In addition, the barrel and chamber were chromed on the inside, another rust retardant. Anti-corrosive features are literally life-saving; in Vietnam, the U.S. military's inadequately protected M16s often jammed because of pitting and corrosion, leaving the soldiers vulnerable to their Kalashnikov-equipped adversaries. "The U.S. Army thought they had a kind of steel that wasn't susceptible to corrosion," Chivers says. "They were wrong. After the U.S. coated the rifle and chromed the inside, the M16 did pretty well."



WAY OF THE GUN

HOW THE AK-47 BECAME THE GO-TO RIFLE FOR INSURGENTS, REBELS AND WARLORDS THE WORLD OVER.



WHAT WE BUILT

→ A
BACKYARD
RINK
CAN BE
MUCH
MORE
THAN A
PLACE TO
SKATE.

home ice

by LARRY WEBSTER
photographs by NOAH KALINA



➔ More than 175 linear feet of lumber, 25 metal stakes and a 50 x 100-foot plastic liner were used to construct the rink. Here, the author and his daughter enjoy the finished product.

ohn, my 7-year-old son, and I crisscross our backyard, pacing the boundaries of our would-be DIY skating rink. It's late October, too soon to be thinking about ice. But we've endured a few winters here in Ann Arbor, Mich.—frigid, soul-sucking winters—so we're plotting a way to brighten up the dark months. As the day fades into twilight, we kick paths into the fallen leaves, defining the rink's edges. An ambitious kid who's towheaded like his mom, John skirts the far reaches of the yard.

My wife, MaryLinda, emerges from the house, holding our other son, Sam, 1; our daughter, Abby, 5, trails behind. "Wow, that's going to be a huge rink," MaryLinda says. Abby frolics in the leaves, obliterating John's and my work. John throws up his hands, yelling, "Aaaah-beee!" It's still just a notion, but the rink is already doing its job.

Before MaryLinda and I had kids, I survived the cold months in Michigan with a garage project, like rebuilding a car. But now, holing up solo wouldn't cut it. The rink harked back to my childhood pond-hockey days and seemed like the perfect solution. I hoped it would get us all out of the house, while serving as a beacon for the neighbors, most of whom we still hardly knew after nine years.

But there was a problem: Our backyard slopes down about 3 feet over a 60-foot stretch from the back of the house. Any reasonably sized rink would need a stout retaining wall at least 2 feet high at the deep end. That would call for more water—and more construction—than I had in mind.

"Let's use the driveway," John suggests, an idea I consider until my wife asks where we'd park the cars.

"On the street, of course," says John.

While preparing to tell John the many practical reasons his proposed solution won't work, my gaze wanders next door, into the Browns' backyard.

When Chris Brown, 48, and his family arrived, in 2005, they turned the rolling, wooded space into a soccer pitch, complete with full-size goals. In above-freezing weather, it was a great place for their two teenage sons to hone their considerable skills. But it went unused all winter, so...

"Let's go talk to Chris," I say to John, and we amble over. Since no one in Chris's family skates, I mentally work up a spiel about why they need a rink in their yard. We say hello to Chris, and I start in with tales of my recreational hockey exploits, segueing into a sermon about the value of teaching our kids how to make the most out of winter's harsh reality. My coup de grâce is a quote from snowboard innovator Jake Burton, who said, "I tell my kids, 'Bring it!' Winter's just another thing to bring you down." In other words, when life gives you frigid temperatures, make ice.

"Fantastic!" Chris exclaims. "Let's do it."

Startled by his enthusiasm, I warn that the rink might leave a mark when we dismantle it in the spring. Undaunted, Chris says, "Hey, man, we've got the space, let's use it."

ENLISTING THE TROOPS / With my rudimentary rink drawings at hand, I poke around the Web for plans that might show me something I've overlooked. My sketches call for a plastic-lined, 40 x 60-foot box made out of 2 x 12s conjoined by sheet-metal tie plates and held upright by iron stakes. I'm proud of the rugged simplicity—until I see the NHL-worthy rinks built by other backyard DIYers. The only thing they lack is a Zamboni. But for a time-challenged father of three, I reason, rugged simplicity is the way to go.

My plan relies on the field being basically flat, with the foot-wide planks accommodating any slope invisible to the eye. Knowing I'll need at least 3 inches of ice for a stable skating surface, I figure I'll have 9 inches of wiggle room. It all seems about right—but I wake up one night, terrified that my crude calculations will lead to disaster. I need a transit, a gradient-measuring device. I call Dave Ferguson, an architect friend. He drops by in early November, and we stake out a detailed grid, using his trusty transit.

Good move: The gradient of the rink location turns out to be a full 12 inches, so one end would be full to the brim and the other dry. We relocate the grid to an area with an 8-inch gradient. "That'll do," I think. But Dave isn't finished. Two days later he e-mails me a computer-generated drawing of an oval rink and a list of building materials. His plan is far more elegant than mine, with boards of varying widths to bring the ice flush with the border.

Dave's enthusiasm gets me thinking: If I ask enough people for help, I could Tom Sawyer the whole thing. But I also have a bigger idea in mind, another vestige of my youth. I grew up in New Jersey in the '70s. We lived on a dead-end street of modest, single-story homes. The Garden State's image has long suffered because of a foul, industrial corridor along the northernmost stretch of the New Jersey Turnpike, to say nothing of the stereotypes perpetuated by *The Sopranos* and—heaven save us—*Jersey Shore*. That's not my New Jersey. In our neighborhood a strong work ethic and a propensity to help one another prevailed. The dads joined forces to build decks, replace sinks and finish basements. In one epic project, they plumbed all the houses to a new sewer line.

Ever since I moved to the reputedly friendly Midwest, I've been surprised not to find the neighborly spirit of my youth. Maybe, I decide, someone just needs to inject a little community spirit—someone with an ice rink to build. I pick a date when I think most people will be free—the day after Christmas—order the materials and spread the word.

BUILT TO THRILL / Boxing Day dawns at 15 degrees with the threat of light snow. As I gather my tools, I fret about who'll show up. I know I have enough hands to finish the setup in one day. In addition to Dave and Chris, another eager neighbor, Doug, even offers to split the \$750 I spent on



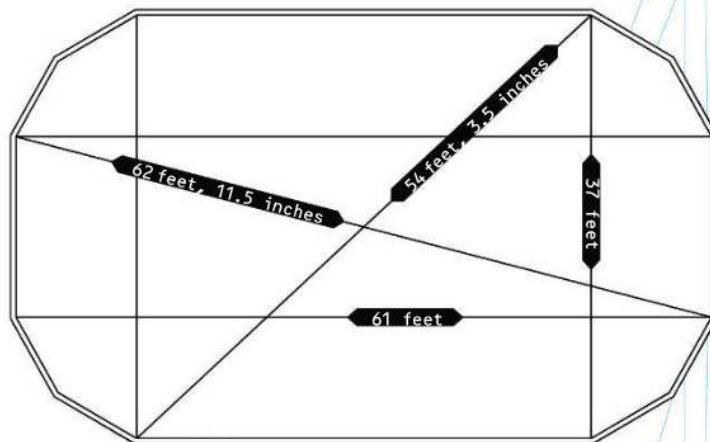
WHAT WE BUILT



→ Dave Ferguson, an architect, holds his computer-generated rink plans, which feature pinched-in corners to approximate an oval. The superiority of this design over a rectangular one became evident when the first puck zinged around the curve rather than lodging in a corner.

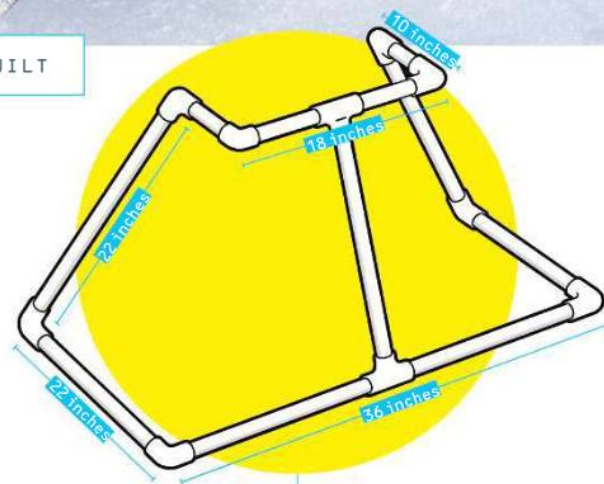
TIPS

→ **Above:** As with any project, you learn as you go. Some lessons we took away from the rink build: Circular-saw blades designed for pressure-treated lumber cut far smoother and faster than typical crosscut blades; cordless-drill batteries drain quickly in the cold, so keep the chargers nearby; build the rink before the first frost—your hands will thank you, and it'll be easier to get a tight fit between the wood and the ground.





WHAT WE BUILT



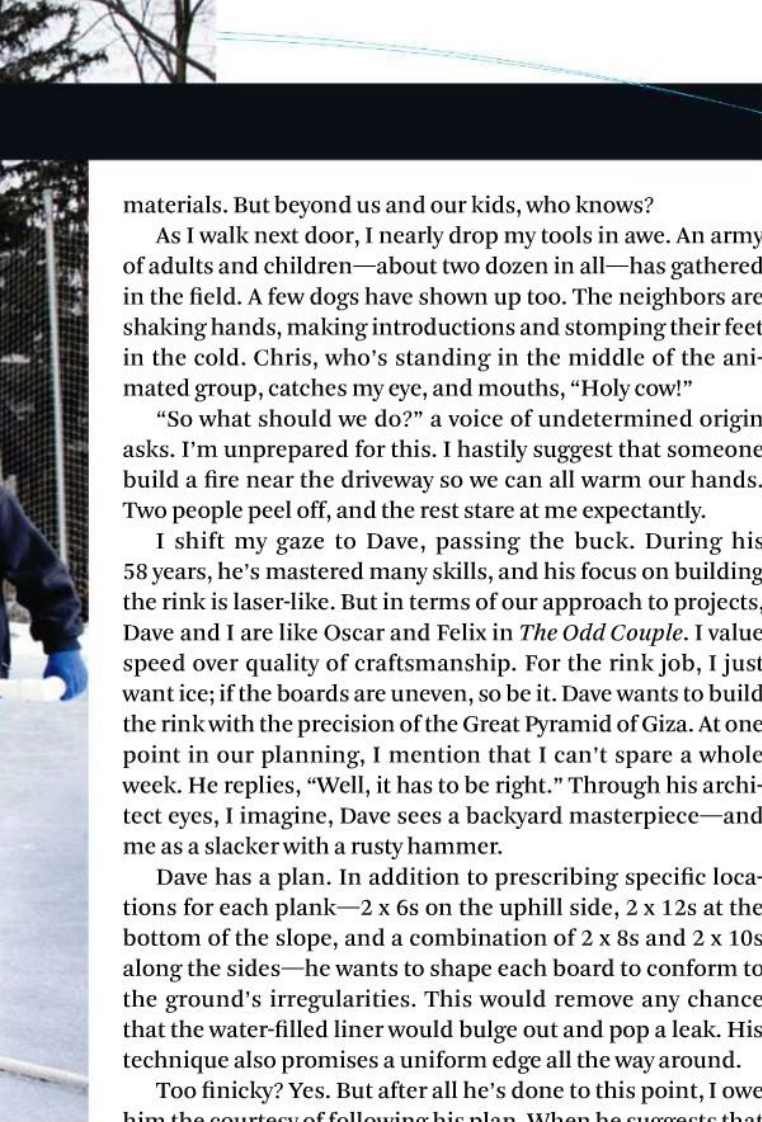
→ **Top:** The author, flanked by (from left) two of his children, Abby and John, and neighbor Tommy Brown. **Top left:** Decking screws driven through metal tie plates and into the wood connect the retaining boards. **Bottom**

left: Chris Brown gets a kick out of watching his son Jack perform the heavy lifting.

TIPS

→ A plastic lawn chair can support beginning skaters while they learn to gain their balance on the ice. Even better, a custom-built trainer surrounds the skater and provides more stability. We cribbed this design from a local indoor rink, modified the dimensions for our kids and constructed it with 2-inch PVC pipe and fittings. Using sheet-metal screws instead of PVC cement imparts flexibility.

ILLUSTRATIONS BY MERCE IGLESIAS



materials. But beyond us and our kids, who knows?

As I walk next door, I nearly drop my tools in awe. An army of adults and children—about two dozen in all—has gathered in the field. A few dogs have shown up too. The neighbors are shaking hands, making introductions and stomping their feet in the cold. Chris, who's standing in the middle of the animated group, catches my eye, and mouths, "Holy cow!"

"So what should we do?" a voice of undetermined origin asks. I'm unprepared for this. I hastily suggest that someone build a fire near the driveway so we can all warm our hands. Two people peel off, and the rest stare at me expectantly.

I shift my gaze to Dave, passing the buck. During his 58 years, he's mastered many skills, and his focus on building the rink is laser-like. But in terms of our approach to projects, Dave and I are like Oscar and Felix in *The Odd Couple*. I value speed over quality of craftsmanship. For the rink job, I just want ice; if the boards are uneven, so be it. Dave wants to build the rink with the precision of the Great Pyramid of Giza. At one point in our planning, I mention that I can't spare a whole week. He replies, "Well, it has to be right." Through his architect eyes, I imagine, Dave sees a backyard masterpiece—and me as a slacker with a rusty hammer.

Dave has a plan. In addition to prescribing specific locations for each plank—2 x 6s on the uphill side, 2 x 12s at the bottom of the slope, and a combination of 2 x 8s and 2 x 10s along the sides—he wants to shape each board to conform to the ground's irregularities. This would remove any chance that the water-filled liner would bulge out and pop a leak. His technique also promises a uniform edge all the way around.

Too finicky? Yes. But after all he's done to this point, I owe him the courtesy of following his plan. When he suggests that the two of us custom-fit the first board, to teach everyone else, I go along. As we mark, trim, test fit and retrim the lumber, our volunteers stand around, attempting to blow frosty smoke rings in the icy air. After a half-hour of tedious, finger-numbing work, Dave and I finish board one. The crowd dissents. "Skip the trimming—it's gonna take all day, and I've gotta drive my kid to practice later," says Sam from across the street. Nods all around. A walk-off strike looms. But Dave holds fast, claiming that once we get the process down, the rest will be easy.

That proves optimistic. Owing to frozen tufts of grass, our fitted pieces fail to eliminate the gap between the wood and ground. A tight fit would require hours of adjustments. Dave relents, saying, "This will take longer than I thought."

What's that I hear? A collective sigh of relief? Now all we need to do is place the boards according to Dave's blueprints, screw in the tie plates and drive the stakes. The crew splits into two work groups, and the yard beehives with activity. Chris's wife, Nancy, arrives with hot chocolate and doughnuts. As if cued by a Hollywood director, a light snow falls. Four hours later, with the planks securely in place, everyone races into the Browns' house to thaw out.

FINISHING TOUCHES / Who knew freezing water could be so complicated? When I researched rink building, the consensus seemed to be that obtaining

billiard-table-smooth ice requires a multistage layering process. Pour in some water, let it freeze, add more water, and repeat until the desired depth is achieved. Most seemed to think that this is best done during an all-night session, when the sun won't slow the freezing. Crazy, right? Even an endless supply of my favorite frosty beverage wouldn't make a night spent with a garden hose remotely interesting. Given cold enough temperatures, water freezes. End of discussion.

After Chris and I staple the plastic to the boards the following day, we turn on the hose. Nearly 18 hours later, the rink is full but, Houston, we've got a problem. At the deep end, where the water is 10 inches deep, the pressure has forced the plastic through the gap between the wood and grass, and there's a trickling leak. We thought we had prepared for this by packing the gaps with snow, but it seems my quick-and-dirty approach has put the dirt on my face. Not ready to concede the superiority of Dave's fastidious methodology, I dash inside and check the forecast: temperatures in the teens or lower for the rest of the week. For the first time in my life, I rejoice in the cold. Over the next few days, I inspect the breach like a prison guard. By day three, it and the entire rink are frozen solid.

The job, however, is not done. The evening of our first skate, Dave drops by with a pair of spotlights mounted on 20-foot-tall boards. We secure the lights to the now-unused soccer goals. More donations pile in. Two benches appear alongside the ice. A neighbor from two doors away who missed the construction day presents a wide, sharp shovel perfect for clearing ice shavings. Another drops off a pile of hockey sticks and a bag of pucks. A week later, I fabricate two skating trainers out of PVC pipe (see diagram) for the beginners.

SKATE-O-RAMA / For a guy who waited 48 years to lace up his first pair of blades, Chris is now all about the ice. He's still shaky and lands on his backside so often we joke about calluses. But after four weeks, he never misses our Saturday morning adults-only hockey games. We have room for three-on-three play, and a couple of the neighborhood guys are so good we make them play with the small ends of their sticks. Without the rink, I would have had no way to find out about their hockey skills. Nor would I have discovered that Clayton had played offense and defense for the Michigan football team, or that Charlene once figure-skated competitively and can still perform dizzying pirouettes.

Except for the adult hockey games, the younger set rules the ice. Every evening I arrive home and am greeted by two kids dressed for action. The Browns generously institute an open-door policy, so the rink is always open. Most nights, there are a half-dozen kids and parents gliding around. Folks out walking their dogs stop by to have a look and say hello. Because of the rink, we've met more people in three months than we had the previous nine years. And this is during the winter, when we used to burrow indoors, a happy family, to be sure, but a family unto ourselves.

We used to curse the cold. Now we hope it lasts through April. When the ice melts, we'll drain the water, dismantle the rink and wait anxiously for the mercury to fall again. **PM**

THE
RACE
TO

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TUCKED INTO THE WOODS NEAR THE top of Rattlesnake Hill, in eastern Pennsylvania, is a 19th-century iron-ore mine. Heavy steel slats bar the mine's gaping black mouth. Beyond a hinged gate, down a rubble slope, where the entry tunnel opens into a dark chamber, Pennsylvania Game Commission biologist Greg Turner aims the beam of his headlamp upward, illuminating hundreds of bats clinging to the ceiling. Moisture beading on their brown fur glistens as Turner inspects each one, searching for signs of a killer.

During a normal year, an estimated 10,000 bats winter in Durham Mine, one of the state's largest hibernacula. The bars have kept humans out for 16 years, but they are useless against a new and far more sinister threat, a condition known as white-nose syndrome, or WNS. In a mere season or two, WNS can wipe out nearly every bat in a colony. Internet forums used by cavers and wildlife conservationists bristle with doomsday proclamations such as this: "Whatever is going on, it is evil, like the black plague. Birds are now ripping the bats apart . . . like something from the Book of Revelation."

All told, WNS has killed up to 2 million bats from eastern Canada to Tennessee, with no signs of slowing. If it continues, scientists warn, WNS could result in the biggest decimation of a natural population since the extinction of the passenger pigeon. But while the passenger pigeon was only one avian species out of 10,000, collectively, bat species make up 25 percent of the world's total mammal types. Of the 45 North

AN EPIDEMIC HAS WIPED OUT MILLIONS OF BATS ACROSS THE U.S. AND CANADA. TO SAVE THE REST, SCIENTISTS MUST QUICKLY FIND ITS WEAKNESS.





Pennsylvania Game Commission biologist Greg Turner holds a little brown bat near the entrance to Durham Mine in Bucks County, Pa. Scientists estimate this species may be extinct in the northeastern U.S. within 16 years.

By Logan Ward **Photographs by George Steinmetz**

American bat species, WNS threatens more than half. The epidemic affects humans too: A single bat can eat up to 600 insects a night. The bats killed by WNS in 2009 left enough insects uneaten this year to fill 693 tractor-trailers; those include pests that will spread disease, destroy crops and require more chemical pesticides to keep them in check.

"It's absolutely dire," Turner says. "I'm seeing bat colonies I've watched grow for the last eight years bite the dust." Another iron mine in Pennsylvania formerly housed 2317 bats. "I went back a year later and found one bat," he says.

Turner has come to Durham Mine to conduct the first-ever field test of a treatment to stop WNS. He's been joined by two other scientists: Northern Kentucky University's Hazel Barton, one of the world's few cave microbiologists, and Bucknell University biologist DeeAnn Reeder, an expert in bat immune systems. All three wear disposable white Tyvek coveralls to reduce the risk of contaminating other sites with the syndrome—if, that is, they encounter diseased bats. As recently as two months ago, the mine was clean.

Turner's beam passes along the ceiling, and then it stops. Frowning, he reaches up and gently removes a bat with a white snout and speckled-white wings.

"I guess you answered your question about whether the fungus had arrived," Barton says. Turner euthanizes the bat and slides it into a specimen tube for later verification.

One by one, the scientists belly-crawl through a 12-inch gap between rocks left by a ceiling collapse and then make their way to a pair of chambers deep underground where they will set up their experiment. In one chamber, 16 bats will be enclosed with a plant compound; the other will hold 16 bats in a control enclosure. It's October now. In six months, the team will return to find out if it worked.

Hibernating bats are finicky. They've evolved to winter in caves and mines, which have a climate more consistent than any place on earth. They breathe only four times per minute and are sensitive to the slightest fluctuations in temperature and humidity. But in February 2006, a caver in Howes Cave, near Albany, N.Y., witnessed something strange: hibernating bats whose faces were dusted with a white powder. State biologists observed bats behaving erratically, rousing early and venturing out into the cold, where many died. Before long, bats in Vermont, Massachusetts and Connecticut were acting the same way.

At first, scientists assumed the powder-like fungus was only a symptom of an underlying syndrome—a parasite taking advantage of a weakened immune system the way pneumonia afflicts those infected by HIV. By the spring of 2009, David Blehert, a microbiologist with the U.S. Geological Survey's National Wildlife Health Center, had classified the fungus as *Geomyces destructans*, a previously unknown cousin of a number of harmless species. Barton and others suspect the fungus hitched a ride on muddy spelunking gear to the U.S. from Europe, where bats appear to be resistant to it.

Although it has yet to be proved, the fungus may instead be the root cause of WNS. And rather than killing bats directly, some scientists theorize, it wakes them early from hibernation, causing their body temperature to rise and



Cave microbiologist Hazel Barton, from Northern Kentucky University, inside a bat enclosure in Durham Mine (above). Bucknell University biologist DeeAnn Reeder examines a little brown bat outfitted with a data logger that measures body temperature (top right).

Despite the name "white-nose syndrome," a bat's wings may be the most vulnerable point of fungal infection. The wing membranes—85 percent of a bat's surface area—regulate body temperature, blood pressure, water balance and gas exchange.



HOW TO STOP THE SPREAD

Cavers may have helped transmit deadly white-nose syndrome (WNS) by transporting fungal spores on their gear or clothing. Here's how to keep it in check.

1

Observe Cave Closures The U.S. Fish & Wildlife Service advises not to cave in states with confirmed cases of WNS, in adjoining states or during hibernation. More information and a map can be found at fws.gov/whitenosesyndrome.

2

Report Unusual Behavior Warn your state's natural-resource agency if you see bats flying during the day or roosting in sunlight on the outside of structures, especially from December to March, during hibernation.

3

Disinfect Gear Wash dirt from clothing, footwear and gear using Woolite. Then soak for 10 minutes in Lysol Professional All Purpose Cleaner, Formula 409 or a 10 percent solution of household bleach. Rinse well and air-dry.

their metabolism to increase. Many bats starve while searching for insects that won't return until spring.

To stop WNS, logic might follow, kill the fungus. But Barton fears the knee-jerk application of a broad-spectrum fungicide. "Microorganisms are at the bottom of the web of life," she says. "Whip that rug out and the whole ecosystem falls apart." That's precisely what happened in France's Lascaux Cave in the 1960s. To stop microbes from eating away at the 17,000-year-old cave paintings, panicked officials sprayed the cave walls with a disinfectant. "They created a clean slate for invasive species to come in and do 10 times the damage they were doing before," Barton says.

In her lab Barton began searching for a treatment that would kill *G. destructans* without harming other cave life—a firewall to stop the fast-spreading epidemic. The only other attempt to do so was a lab-based experiment by another scientist that featured terbinafine, a chemical found in athlete's-foot cream. The test was a flop for many reasons, not least of which was that all the bats died. Barton homed in on a natural antifungal called carvone, produced by the spearmint plant to keep its roots from rotting. Unlike the synthetic drug, which requires direct application, carvone permeates a cave—at least, that's the theory.

In April, the scientists hike back up to Durham Mine. They squeeze through the first tight pinch and crab down a talus slope, careful not to send soccer-ball-size rocks tumbling. "Don't touch anything," Barton warns. "Almost everything you see on the ground used to be on the ceiling."

Some 600 feet into the main passage, the team reaches the first enclosure—the control experiment. Because no one has ever attempted to confine hibernating bats for underground drug trials, Turner had to improvise. To create a cage, he stitched together sheets of netting and pinned them to the ceiling with telescoping aluminum poles from a drywall-dust-barrier system.

Barton lifts the black netting and starts looking for bats with lime green, lozenge-size data loggers glued to their backs. Every 10 minutes the devices record the bats' body temperatures, which can jump from 40 F during hibernation to 98 F upon arousal. Reeder had attached the data loggers to learn whether the bats were behaving normally.

But the enclosure appears to be empty. Reeder joins the search, and after 15 minutes, they've found only two of the original 16 data loggers, one glued to the back of a live bat and another to an Oreo-size smudge of fur and bones.

As the team advances into a deeper chamber, the fresh scent of Wrigley's gum begins to drown out the earthy odor of microbial growth. Inside the second enclosure, Barton and Reeder inspect a wooden box that holds an inverted bottle of carvone—the source of the minty aroma. That cage, too, is empty. "I had this vision," Barton says wistfully, "of 16 bats alive and well inside the netting, with lots of others on the outside huddled around this place of safety."

Barton and Reeder collapse the enclosure, and Turner heads farther into the mine to search for the escaped bats, at one point descending a 20-foot ledge using a climbing rope and cable ladder. He sees hundreds of bats, but none with data loggers. WNS has infected roughly 50 percent.

Mud-caked and dispirited, the scientists emerge from the mine and head back down Rattlesnake Hill. At the bottom, as they huddle on the highway shoulder peeling off gear, a rusty Ford pickup rumbles to a stop. The driver leans forward: "Were you guys up at the mine checking on the bats?"

"Yeah," Turner replies.

"How are they?"

"Half of them are dying," Turner says, "which is actually pretty good."

Failure is a routine part of science, but the relentless sweep of white-nose syndrome makes today's disappointment especially painful. Still, even before the three have sealed their contaminated gear in oversize Tupperware bins, they've begun plotting another drug trial. Turner and Reeder agree to haul lumber and plastic netting into the mine to build escape-proof cages, and Barton vows to bring an arsenal of targeted antifungal compounds. Next spring, they hope, the bats' outlook will be better.

PM

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Home

EASY

Smooth Operators

WHEN THE DUST SETTLED, OUR TEST REVEALED THE BEST RANDOM-ORBIT SANDER. BY ROY BERENDSOHN

When we set out to test random-orbit sanders, we were concerned there wouldn't be enough to say. After all, sanders are pretty simple, and tool-makers have come a long way since the days when sanders tended to gouge circles whenever they touched a piece of wood. Well, it wasn't the first time our preconceptions turned out to be wrong. While all nine sanders in the test produced an acceptable surface

INSIDE

✱ CHRISTMAS-TREE CARE + TOOL-O-DEX + READER MAIL

RATINGS

PM DIY HOME /// SANDER TEST

finish, some operated far more smoothly than others. And there were other differences as well: Certain models were particularly adept at collecting the sawdust they produced, while others had better ergonomics than their peers. Finally, we

ran a time trial, clocking how long it took each contender to remove a rectangle of paint applied to a medium-density fiberboard panel—there were a couple of real hares in that test. When the sawdust settled, we had a clear winner.



Amps: 2.57
Speed (opm):
7500–12,000
Cord length (feet): 8
Time trial (seconds):
45.5
Price: \$80



Amps: 2.7
Speed (opm):
12,000
Cord length (feet): 10
Time trial (seconds):
54.7
Price: \$100



Amps: 3
Speed (opm):
7000–12,000
Cord length (feet): 8
Time trial (seconds):
45.9
Price: \$90



Amps: 2.4
Speed (opm):
7000–12,000
Cord length (feet): 8
Time trial (seconds):
42.7
Price: \$80

BOSCH
ROS20VS

Likes: Cleanliness. That pretty much tells the Bosch sander's story—it gathered the most sawdust. It's the only model in the test that came with a pleated (automotive-style) prefilter. The Bosch's elongated rubber-coated (overmolded) handle is pleasingly long; you can use two hands if you care to.
Dislikes: The dust lid is difficult to snap down. Double-check that it's snapped, because if it's not, the dust will fly.

CRAFTSMAN
172.25927

Likes: Despite its cool looks, this Craftsman is a power tool of the old school—heavy, smooth and powerful. It operates with the least vibration of any sander we tested, and it makes sanding about as pleasant and dust-free an activity as it can be.
Dislikes: This tool takes a specialized two-piece abrasive disc, not a standard perforated disc. Yes, that seems to greatly improve its dust-gathering ability, but you may not find replacements at your local hardware store or home center.

DEWALT
D26453

Likes: We sometimes refer to DeWalt products as DeFault—they tend to be hardworking, simple, rugged and reliable—a never-fail setting for power tool purchases when you're unsure of what to buy. This sander is a perfect example of how DeWalt built its reputation. It's not flashy, but it works with little vibration and is easy to control.
Dislikes: Try as we might, we can't find a thing to complain about.

HITACHI
SV13YA

Likes: "Overall, it's a decent tool," one of our testers said of the green machine. The shape is easy on your hand, and the high speed makes it easy on your back—you can finish the job quickly and cut the time spent bending over a project.
Dislikes: The funky zippered dust bag has to go. Without an internal support spring, just getting bumped causes it to unload some of its dusty cargo. Unzipping the thing is a messy nuisance.

Time trial: Removed a 6 x 8-inch rectangle of semigloss latex paint applied to medium-density fiberboard.

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RATINGS

PM DIY HOME /// SANDER TEST



Amps: 3
Speed (opm):
 4000–12,000
Cord length (feet): 6
Time trial (seconds):
 46.9
Price: \$80

Amps: 3
Speed (opm):
 7000–12,000
Cord length (feet): 12
Time trial (seconds):
 42.7
Price: \$70



Amps: 3.5
Speed (opm):
 7000–12,000
Cord length (feet): 8
Time trial (seconds):
 39.7
Price: \$100



BEST OVERALL

Amps: 3
Speed (opm):
 7000–12,000
Cord length (feet): 12
Time trial (seconds):
 27
Price: \$70



Amps: 2.8
Speed (opm):
 5000–12,000
Cord length (feet): 10
Time trial (seconds):
 42.4
Price: \$75



MAKITA

B05031

Likes: We can't test for durability, but we suspect this tool would last for years, thanks to details like a well-shielded on/off switch, plentiful air venting and smoothly spinning disc pad.
Dislikes: The dust-collection bag is poorly mounted. You're liable to pull off the bag and its connector when all you wanted to do was remove the bag.

MILWAUKEE

6021-21

Likes: This sander is rugged. Its wraparound dust chute is large, and the dust container mounts with a firm twist-lock motion. The speed-control dial is nice and big, clearly labeled, smartly located and easy to turn.
Dislikes: It was slower in our paint-removing time trial than the nearly identical Ridgid.

PORTER-CABLE

390K

Likes: The Porter-Cable clocked the second fastest time in our paint-removal test owing to a slightly higher amperage than other sanders and an electronic speed control that helps it maintain speed under load. Its low 4 $\frac{3}{8}$ -inch height, about an inch or so shorter than average, helps if you have to sand between shelves or if you simply prefer a tool with a low center of gravity.
Dislikes: The Porter-Cable's dust-collecting chops were only fair.

RIDGID

R2601

Likes: The Ridgid is very fast and runs with a consistency that makes it easy to control and produces an exceptionally smooth finish. The dust-collection bag, which has an internal spring support, is like something out of an industrial design textbook. Slide it on, twist to lock it.
Dislikes: Nothing noted.

ROCKWELL

RK4246K

Likes: The Rockwell is extremely smooth and reasonably fast. It shares the same dust-catcher design as the Craftsman, complete with a spring-loaded trap door to dump the dust. It's a very tidy machine. We also liked the easy-turning speed-control dial with positive stops at each speed setting.
Dislikes: Nothing noted.

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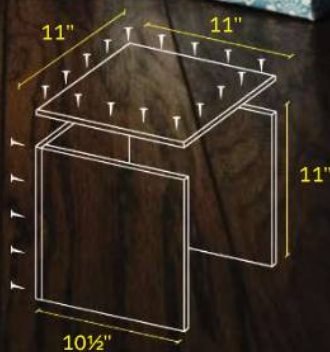
Homeowners Clinic

by Roy Berendsohn

Q+A



Box, built from ½-inch birch plywood, has open bottom and back.



Q

Tree Tactics

What do you recommend for setting up and taking down a Christmas tree? You'd think we'd have this figured out by now. Every year we buy a tree and every year it's a disorganized mess, especially when it's time to take the tree out and the needles fall all over the floor. Thanks for the help.

A Christmas is fast approaching, but you still have time to gather a small kit to handle the job of setting the tree up, keeping its stand filled with water and taking it down without blan-

keting the house with conifer needles. Then you can keep the tools together for next year. I'm a big fan of kits for specific jobs like this—I've got one for gutter cleaning and another for dryer-vent maintenance, among others. Not only does it keep you from having to hunt for the right tools, the kit reminds you of the steps involved: You don't want to reinvent the Christmas tree process every December.

One innovation in my tree kit is a box to conceal a plastic gallon water jug. My wife or kids wrap the box to look like a present so it blends in. I learned years ago that I'm more likely to keep the tree watered if I keep a filled jug on hand. When I get a spare moment, I check the tree's water level and add a bit if necessary. A well-watered tree loses fewer needles (making cleanup a lot easier) and presents less of a fire hazard than a dry, brittle one.

Water monitoring aside, you should always buy the freshest tree you can find (assuming that you don't cut a tree, that is). When I shop for a cut tree, I pick a tree up and firmly thump its stem on the ground to check for falling needles. I also run my hand along a couple of branches to test how firmly attached the needles are and how fresh the tree seems. If either test drops a lot of needles, I don't just move on to another tree, I go to another vendor, reasoning that many of the trees in the lot were probably cut at the same time and saw the same level of care. For what trees cost these days, I expect maximum freshness. Once I get the tree home, I cut the stem to expose fresh wood, and keep a close eye on the tree for the next 48 hours because it's going to soak up water like a sponge. The bigger the tree, the more pronounced the effect.

Other items in my tree kit include the jug and a tree-disposal bag (a reusable sack that closes up over the tree as you carry it outside). These are readily available on the Web and through specialty retailers. If you don't want to get one of these bags, you can just wrap a tarp around the branches. No matter how fresh your tree is or how well you take care of it, it's bound to leave behind some needles. I use a small shop vacuum to pick these up, instead of a regular house vacuum.

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The Universal Wood Screw

My father-in-law is a former remodeling contractor, and he uses drywall screws for just about every job, indoors or out. For example, he just used some to fasten a bathroom vanity cabinet to the wall. Are drywall screws strong enough for that?

As the 5-gallon bucket is to hauling tools and hardware, the drywall screw is to general small-job fastening. Everybody seems to have some drywall screws lying around, and they get used for a wide range of jobs. The screws should be fine, especially if the vanity is sitting on the floor and the screws are long enough to penetrate well into the stud—at least an inch or more.

On the other hand, drywall screws aren't ideal for every job. For one thing, they are case-hardened. That means that their outside is much harder than their inside. While that makes them stand up to the rigors of being driven

with a drywall screw gun, it makes them undesirable in assemblies that see complex loads, such as bending, twisting and shear forces (parallel forces that move in opposite directions).

I'm not saying that drywall screws are weak. They're not. In fact, it takes at least a couple of hundred pounds of force to pull one out, and even more to shear one away. But they are brittle compared with nails, bolts and other types of wood screws: Hit one just right, and you can snap it off. Additionally, a drywall screw's phosphate coating gives it only fair corrosion resistance. I've seen many badly rusted drywall screws used in outdoor projects. And don't even think of using them in pressure-treated lumber, where they will rust away in no time. (Take away your father-in-law's drill driver if he tries to use drywall screws to assemble a swing set for the kids.)

Also, you'd never use a drywall screw to fasten structural components, such as a header over a door or window. The

humble and low-tech common nail, which will bend rather than snap, is more resistant to the structural forces that a house will encounter. Any building code will tell you the same. The average house frame is held together with many pounds of common nails, especially large ones (16d, for example).

The Coverup

We have a through-the-wall air conditioner. We cover it with a sheet of plastic in the winter, but it still creates a cold spot in the room. Ideas?

The hole for a through-the-wall air conditioner creates a huge gap in the house's insulation envelope. That gap can't be adequately insulated, even with the typical insulated covers they sell at the hardware store. One solution is to build a tightly fitting box of ½-inch exterior-grade plywood lined with polystyrene insulation that fits outside the air conditioner and butts up closely to the house's siding.

You could also try a plastic cover on the inside (such as the Chill Stop'R), combined with insulated drapes. If you take this approach, keep an eye on the

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wall surface for condensation. If it forms, that's a bad sign. You run the risk of mold and rot. Open the drapes to let the area dry out.

Oil to Gas

We like our oil-fired boiler, but we're thinking of switching over to gas, since we already use gas for our kitchen range. Is it possible to do this?

An oil-fired boiler or furnace can usually be converted to gas. This should be relatively easy to do, since you already have a lateral gas line running to the house to serve the kitchen range. "An oil-to-gas conversion is very feasible, especially if the boiler is less than 10 years old," says Tom Tubman, executive vice president and general manager of Carlin Combustion Technology, a manufacturer of heating-system burners and controls in East Longmeadow, Mass.

If the boiler is more than 10 years old, it probably makes sense to replace it with a more energy-efficient model. Let's say the conversion costs \$2500 to \$5000—you wouldn't want to spend that much money on an old, inefficient boiler. To get a better sense of the eco-

COOL TOOLS SEASON PREMIERE

PM'S GRUNDY AWARD

• The movie industry awards the Oscar; TV hands out the Emmy. Now, PM presents the Grundy, which honors outstanding achievement in toolmaking. Named for contributing editor Chris Grundy, host of the DIY Network's *Cool Tools* show, the Grundy is one of the PM Editor's Choice awards. After reviewing hundreds of contenders, PM recently presented 11 Editor's Choice awards at the National Hardware Show in Las Vegas.

The inaugural Grundy went to the Dremel Trio, a new form of rotary tool. "Sounds weird, I know," Grundy says, "but the Trio is like the club sandwich of power tools. A good club has got everything needed to make you



happy—turkey, bacon, you name it. The Trio is like that. It cuts wood, drywall and light-gauge sheet metal and sands and shapes. The Trio does whatever you need. It's amazing."

Other 2010 Editor's Choice winners include a pocket-size rotary

hammer, a folding LED worklight and the Arnold Gadget—a combination socket wrench, spark plug feeler gauge, screwdriver and bottle opener.

Readers can follow Grundy and a PM team consisting of senior editor Roy Berendsohn, associate editor Harry Sawyers and contributing editor Joe Truini by tuning in to the DIY Network's *Cool Tools* "The Hardware Show" at 8 pm ET on Thanksgiving (Nov. 25). The one-hour special kicks off season six of the series. When it comes to hardware, there's no way that what happens in Vegas stays in Vegas.

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nomics, check with your gas utility. Many are offering rebates and other incentives for conversions.

The fact that the job is straightforward doesn't mean it's a DIY project, however. "It's a job for a technician with above-average skills," says Pat Porzio, a regular clinic contributor and HVAC manager for Russo Brothers & Co. in East Hanover, N.J. The burner has to be sized properly for the boiler or furnace, and the combustion chamber needs a thorough inspection, as does the connection between the heating plant and the house's flue.

Then there's the removal of the existing oil tank, and you'll want a chimney

sweep to install a flexible stainless-steel liner into the flue. The flue's probably in bad shape, but no matter what, a liner is a good idea. It will provide a smooth and leak-free exit path for flue gas.

"And don't forget to remove the oil fill and vents," Tubman says. Often, the town requires that the fill tube and vent be removed when the furnace or boiler is switched to gas. Regardless of whether this requirement is in effect where you live, it's a good idea: There have been incidents in which oil has been mistakenly pumped through a disconnected fill tube, resulting in a few inches of No. 2 fuel oil covering a basement floor.

FROM OUR READERS

TIPS, ADVICE, ANALYSIS

Direct-Vent Water Heater Pilot Light

→ If you've ruled out the thermocouple as the reason a heater won't stay lit ("Water Heater Cuts Out," August 2010), often the pilot itself is to blame. A weak flame won't supply enough heat to the thermocouple. In turn, this doesn't create enough voltage to keep the electromagnetic coil properly energized (if the coil becomes de-energized, gas flow to the heater is cut off). The solution is to remove the pilot assembly and clean it. This creates a more robust flame, which heats the thermocouple properly. A strong gust of wind is another likely cause of pilot-flame failure. It can blow through a water heater's vent terminal on the side of the house with enough force to knock out the pilot. In my area, we have a prevailing north wind, so we avoid installing these vent terminations on north walls.

*Peter (last name withheld)
Kapuskasing, Ontario, Canada*

Drill Bit Know-How



→ The most important information to relay about drilling into metal is how the bit should be used ("Drill Down," February 2010). Don't push down with too much force. Instead, let the bit's high-speed action do the work. **Keep the bit cool by spraying some oil or cutting fluid in the drill hole or on the bit itself.** If need be, stop occasionally to let the bit cool. The bit should be humming along fairly quietly as it smoothly ejects metal shavings from the hole. If the bit is screaming, it's getting way too hot. Once the bit gets heated beyond its working temperature, it becomes annealed (heat-softened) and will no longer cut properly unless its tip is ground back to metal beyond the heat-affected zone.

*Robert Janca
Richmond, Calif.*

Adding Traction

→ I've added sand to garage floor paint ("Slippery When Wet," February 2010), as you have advised, but found that the sand settles quickly to the bottom of the pail or the roller tray. An alternative is to roll out a 4-foot-square area, then sprinkle sand over the freshly applied paint. Then go over it again with the roller to even out the sand coverage.

*George Fogg
Greenville, Maine*

Goofy GFCI

The previous owner of my house installed an exterior floodlight and controlled it through the Test/Reset buttons on an outdoor ground fault circuit interrupter (GFCI) outlet. I have no idea how it's wired. What do I do with this now?

Call an electrician. It's bizarre and an electrical code violation. Devices with a UL listing are safety-tested based on their intended purpose. Electrical codes require installation consistent with that purpose. A GFCI outlet was never meant to be used as a switch. The electrician will replace the existing nonsense with a GFCI outlet and floodlight circuit that are wired correctly.

Cabin Water

I'm looking for an old-fashioned, hand-operated cast-iron well pump for a cabin. I can't seem to find one. Are they still made?

Not only are they still made, but these pumps are newly popular as people look for ways to supply water to rural cabins or to cope when the power goes out.

You can buy small, 18-inch-tall pumps (\$40 to \$50) through outdoor equipment catalogs. Frequently referred to as pitcher pumps, these can draw water from shallow wells, say, 25 feet or so. More powerful models, such as the Monitor 11HD, by Baker Manufacturing, are sold through plumbing-supply houses. The Monitor stands 5 feet tall and weighs 80 pounds. It costs about \$780—that's expensive, but it can draw water from a depth of 200 feet. **PM**

Got a home-maintenance or repair problem? Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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+ MORE TO DO IN DECEMBER

Prep for Cold →

Batten down for winter with storm windows, weatherstripping on doors and spray-foam insulation in drafty cavities. Use space heaters? No extension cords!

Cut the Tree →

Wisconsin Christmas-tree farmer John Van Ert grows cut-your-own spruces and firs behind his barn. His advice: "Cut straight across. Don't let your 4-year-old carry the saw."

Rev a Classic →

L.A.'s Petersen Automotive Museum auctions rare "automobilia" on Dec. 4. Bid on restored racing helmets, obscure trophies or classic cars—last year a lucky winner scored a 1934 Chevy two-door for \$2500.

Hang the

Bulbs → Bulb stringer Ryan Brand of Christmas Light Professionals says 20-foot strands of C9 and C7 bulbs draw 4 amps. Loading more than three on a line will trip a 15-amp breaker. One burned-out bulb killing the series? Find and replace the dead one with a LightKeeper Pro.

Shine a Light →

Winter solstice, the shortest day of the year, is also National Flashlight Day. Test the torches now, before it's too dark to find a fresh battery.

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Builder: William Gurstelle
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Pipe options: PVC, thin-wall conduit

+ ONE-DAY PROJECT

Tool-O-Dex

TYPICAL WORKSHOP PEGBOARDS ARE TOO SMALL FOR A BIG TOOL COLLECTION. THE SOLUTION? TAKE A CUE FROM THE OFFICE ROLODEX AND BUILD A TOOL-O-DEX, A PEGBOARD FLIP BOOK THAT PACKS 64 SQUARE FEET OF STORAGE INTO 8 FEET OF WALL SPACE. BY WILLIAM GURSTELLE

1 → LEVERAGE WALL SPACE The Tool-O-Dex consists of four 2 x 4-foot pegboards, each attached to a 1-inch-diameter ABS pipe. The pegboard-to-pipe assemblies are held vertically in wooden supports. The individual pegboard sheets swivel, allowing access to tools as needed and folding flat against the wall when not in use.

2 → SPLIT SPINES Start by carefully cutting straight slots lengthwise in four 5-foot lengths of ABS pipe using a table saw. To do this, first bolt the ABS pipe to a scrap 2 x 4 and lower the blade height so the saw's teeth will cut the plastic but miss the bolts. Once the slot is cut, remove the 2 x 4 and pound pegboard into the slot with a rubber mallet. Secure the pegboard to the pipe with five evenly spaced 1½-inch No. 10 bolts.

3 → STIFFEN PEGBOARDS To stiffen the panels, attach wood or metal strips to the edge of the pegboard opposite the ABS spine. Drill five evenly spaced holes in the strips

and pegboard; use No. 10 bolts and nuts for assembly.

4 → ADD SUPPORTS Scraps of 2 x 6 lumber form blocks that support the Tool-O-Dex's ABS spines at the top and bottom. To make the bottom support, use a spade bit to drill four 1½-inch-diameter, ¾-inch-deep mortises into an open-sided box made of five 2 x 6-inch wood blocks. Screw shelf brackets to the box, and drive 4-inch lag bolts through the brackets and into the wall studs. For the top support, drill 1½-inch holes through a 2 x 6. Fit the pipes in the bottom support and slip the top board over the pipes. Cap the pipe ends. Use 4-inch lag bolts and shelf brackets to fasten the top support to the wall studs.

5 → HANG TOOLS Use pegboard hooks to position your tools. For large items, such as circular saws, cut a tool-size hole in the front or rear pegboard page, then hook the tool above the hole. The extra space will allow the page to fold flat.

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Make your hybrid's
battery pack
safe by removing
the service plug.

Working on Hybrid Vehicles

WORKING ON HYBRID HIGH-VOLTAGE, HIGH-AMPERAGE CIRCUITS. BY MIKE ALLEN

➔ **The used-car dealer's offer** is just too tempting: a clean-looking hybrid sedan for a great price. The gas-electric hybrid system works perfectly, and the previous owner has thoughtfully provided fuel receipts that prove the egg-shaped little car is consis-

tently capable of 40-plus-mpg fuel economy. The only problem is that the internal combustion engine has blown a head gasket, but the price asked by the dealer is tasty enough that you can easily fix that yourself and still be ahead of the curve.

Limping the wounded critter home from the dealer is undramatic, the gasket set is a reasonable price, and the flat-rate manual says the job can be done in one day. Figure four days for a DIY job—one afternoon to pull the head, a couple of days in the

INSIDE



HYBRID SAFETY + CHECK ENGINE LIGHTS + JUMPER CABLES

PM DIY AUTO /// HYBRIDS

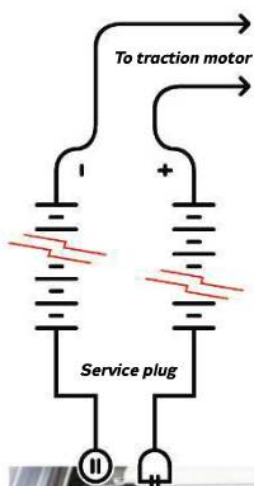
machine shop getting the head rebuilt and another day to reassemble—and you'll be ready to drive in gas-sippin' style while thumbing your nose at Big Oil. Sweet.

Until you open the hood to take it apart. Warning labels with lightning bolts, orange "DANGER" placards and strange-looking boxes full of electrical gadgets threaten to turn your fingers into kielbasa and your children into orphans. Maybe trying to work on your own hybrid car isn't such a good idea.

Barbecue, Anyone?

➔ **Hybrids, and the upcoming** round of plug-in hybrids, have one thing in common, regardless of the specific type of hybrid power system they use: a big-ass DC battery pack—as much as 280 volts—that's capable of delivering enough current to instantly turn you into a crispy critter. Anytime you are working on one of these vehicles, whether it's on the engine or the body or anywhere near the battery pack or cables, you need to take extra precautions. The DC battery pack is only one source of high-voltage danger. There are also multiple fat cables that run from the pack to the motor controller, and more cables that carry even higher AC voltage—as high as 600 volts—from the controller to the electric traction motor.

Fortunately, the AC side of the circuit is energized only when the electric motor is powered. So your first line of defense is to be sure the vehicle is truly turned off, which is not always obvious. Since one of the gas-saving features of the hybrid is the ability to cut the engine when the car isn't moving, your auto could be ready to go even if the gas engine isn't running. Imagine this scenario: You've parked your car and left the key in the ignition (or even in your pocket, if you've got a smart key) while you tinker. Now—did you remember to turn the car well and truly off? Or is it still in "ready" mode, which is the equivalent of a conventional car idling patiently away? Aside from a discreet light on the dash, there's no audi-



➔ **Disabling the battery pack** is the first step to working on any hybrid or EV. While the full battery voltage, anywhere from 144 to nearly 300 volts DC, is available at the output terminals, battery manufacturers have left us a simple way to deactivate the contacts and safely work on or remove the pack. The battery pack is a long series of individual cells. Somewhere near the electrical center of this string is a service switch or removable plug. Opening this connection breaks the circuit so there's no voltage across the pack's main connection. Regardless, take normal precautions when working around any electrical device with this potential.

ble or tactile confirmation that your hybrid is completely shut off. The engine or the cooling fan could suddenly start—without warning—while you work underhood. That's an easy way to lose a finger, or worse. Make a habit of removing the key from the ignition or, if your car uses a smart key, of keeping it a safe distance away—10 feet or more—to be sure you haven't made a mistake. Similar precautions apply for pure EVs, although those vehicles are still rare at this point.

As always, the factory service

manual specific to your vehicle is the definitive resource for proper repair procedures.

Unhooking the Beast Within

➔ **Internal servicing** of the battery pack, the motor controller and the traction motor is still specialized enough that it's best left to qualified professionals. That doesn't mean that a careful Saturday Mechanic armed with a factory service manual (and a few hand tools) couldn't or shouldn't be able to

swap out a pack or controller if necessary. To do so, the battery pack needs to be disabled before twisting any wrenches. Just as important, it's essential to disable the battery pack before doing any work, whether it's powertrain-related or not, anywhere near the pack or any high-voltage AC components or wiring.

Start at the Bottom

➔ **The first step to disabling** the vehicle is to disconnect the low-voltage battery. Start by writing down the radio presets for later, because they'll evaporate within a few seconds after disconnecting the battery. Also, if your radio has a security code, be sure you have it written down, or you may be forced to visit the dealer to get it working again.

Now you can simply remove the negative clamp from the battery. Do *not* remove the positive clamp, which could potentially short to some nearby ground and strike a pretty good high-amperage spark. The negative clamp is already grounded, so it can't arc to anything except the positive terminal.

Let's Talk Safety

➔ **I'm going to assume** that you have taken the most basic precautions and have your hybrid or EV parked indoors or at least out of the rain and that the work area and the car are reasonably dry. The

battery pack is isolated electrically from the vehicle ground, so the only potential difference is between the two fat orange wires leading from the pack forward to the motor controller. So, unlike working on household wiring, there's no need to work on a dry floor or wear insulated boots. In addition, the pack has its own ground fault device.

Pulling the Plug

➔ **Remove any interior** or access panels over the high-voltage battery pack. Pull on your gloves (see below). Now you can unlock the clamp on the service plug and remove the plug from its socket. You've just disconnected the battery pack from itself internally, somewhere near the middle of the stack of individual cells. This means the voltage that you could measure at the pack's output connectors is zero. If it's necessary to remove the pack, you could stick your fingers into the output connectors safely (although I recommend against it). Our photo car is a Toyota Prius PHEV, which has three battery packs: one supporting the normal hybrid function of capturing energy from braking, and two providing the Prius's short-range EV operation. Consequently, there are three service plugs. Other hybrids use a simple switch on the battery pack, hidden from view, to deactivate and make the battery pack

safe. Again, check your service manual.

When you're done, simply put your gloves back on and insert the service plug back into its socket. You'll need to be sure the plug is fully seated and its locking bail is thrown completely shut. There are additional contacts in the socket that tell the onboard computer the plug is installed and the lock is fully seated. Now you can reinstall any access panels or trim and reconnect the 12-volt battery's negative clamp. Key in any radio security code and the station presets.

Digging In

➔ **Owners of older** hybrid cars may experience a loss of fuel economy as the battery pack ages, leaving many to wonder if anything can be done to restore performance. Usually, only a few of the pack's individual cells—the total number of cells can vary from a dozen to well over 100—are to blame. These bad cells can be victims of dendrite-growth internal shorts, caused by metal-salt crystals bridging the electrodes inside the cells. These cells can sometimes be refurbished by zapping them with a large, high-voltage capacitor, vaporizing the dendrites. The onboard charging circuitry does not have this capability, which is okay since the work is best left to the pros. More often, subassemblies of six to eight individual cells can simply be swapped out. But identifying which cells are bad requires sophisticated test equipment. So what's the DIYer to do? Your best bet might be to remove the battery pack, crate it and ship it to a company that refurbishes battery packs. Prices for a rebuilt or refurbished battery pack vary, from \$400 to \$1200, depending on the problem. That's still far cheaper than the \$1800 to \$5000 for a new one at the dealer.

Why not a junkyard pack? Experience in the field reveals that partially charged battery packs that have been sidelined for a few months have a short life span when returned to service. The weakest cells discharge faster and can even reverse their voltage. That consideration also makes hybrids a poor choice for snowbirds or anyone else whose needs for a car are episodic, not daily.

PM

■ SAFETY FIRST

Insulated Gloves

➔ **Working near the battery pack** should be a low-risk operation if you follow procedures and wear insulated gloves. We bought ours at Grainger, but any electrical-supply house will have an assortment. You need gloves rated for 500 volts, but we generally prefer more headroom—ours are rated for 1000 volts. The thicker rubber is less prone to damage but more difficult to work in. Reserve these

gloves for electrical work—any surface contamination might degrade them, and the smallest pinhole could allow a current leak.

Every time you reach for these gloves, perform this simple test: Cuff the gauntlet of the glove, roll it up a few inches and squeeze it to inflate the fingers and palm area. Any air escaping from a pinhole should relegate these gloves to dishwashing duty.



Car Clinic

by Mike Allen

Q+A



Under the dashboard and somewhere near the driver's knee is your OBD-II port. It's where scan tools and the CarMD diagnostic probe plug in.

Q

Tattletale

I wanted to find out what was wrong with my car, so I went to the auto parts store and borrowed their scan tool for 20 minutes, like you've suggested several times. The borrowed tool, however, just displayed gibberish, so I took it back inside and asked the counterperson what I should do. He suggested that I buy over \$400 worth of oxygen sensors. I must have the word "sucker" somewhere on my face. Got any better suggestions for someone who's not a mechanic and doesn't want to be?

A Over the years, I've tested and used so many scan tools that hooking one up, downloading the data and interpreting a trouble code or three has become second nature. Like any technical skill, the process can be a little daunting at first. Interpreting DTCs (diagnostic trouble codes) and diagnosing the problem isn't exactly rocket science. I dare say it's not necessarily

more difficult than programming the clock on the microwave.

But here's an alternative: CarMD. This \$100 device isn't a scan tool, but it kinda works like one. Plug it into your OBD-II port, under the dash, and let it commune with your car for a minute or two. If there are any trouble codes, it'll display them, but there's more to come.

Now, take it back inside and, using the supplied USB cable, plug it into a computer that has an Internet connection. The device will sync up with CarMD's website, take you to a page that's specific to your car and even give you, in plain English, some insight into the problem. The trouble code you sent me in your lengthy letter was oxygen-sensor-related; specifically, it indicated that one of your four sensors was experiencing a lean condition. Replacing all four sensors would not have repaired the exhaust manifold leak that was admitting extra air to the exhaust pipe upstream of the sensor, mimicking a lean-running engine. CarMD's website would have told you that the leak was the probable cause. That service is included in the price of CarMD, and you can register as many as three cars. It won't turn off your Check Engine light, but once you repair the issue that's toggling the code on, the light should go out on its own. My CarMD lives in the same drawer of my toolbox with a couple of scan tools, and I wind up using it nearly as often.

Scrub-a-Dub

A friend of mine has a 1998 Dodge Ram 2500. The radio, windshield wipers, cigarette lighter, all of the electronic components, can be activated when the truck is turned off and the key is out of the ignition. This just started happening recently when he washed the interior and may have gotten water under the dash.

When he started it the next morning, it was idling extremely high and he couldn't even put it in gear. He wiggled the key in the ignition and it started acting normally, except now all of the components will turn on with the key out of the ignition. We disconnected the battery to see if

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that would reset something, but it didn't work. I think water must have gotten into the ignition and shorted something.

Let me get this straight: Your buddy (sure) washed out the interior of his truck with a hose. And now his electrical system is acting justifiably weird, and he wants to figure out why.

Your supposition is correct; there's water in something that's supposed to be dry. I'd start by going under the dashboard and labeling, then removing, every electrical plug and relay I could find, and drying everything out with a hair dryer. The accessories are coming on because some electrical connection between the key switch and the main fuse box is shorted to a hot lead by water. I'll leave it to you knuckleheads to find out where.

Light Duty

As a retired mechanic, I always figured that the heavier the jumper cables the better. Now I see advertised these

jumper boxes that recharge a battery by plugging into the car's cigar lighter. How can enough power go from the jump box to the battery if it's going through light-gauge wire, circuit boards and who knows what else without any damage? Also, I checked my lighter with a volt meter. It is only live when the key is in the "On" position, not when the key is in the "Off" or the "Start" position. This being the case, how can the jump box work?

These boxes, whether they use an internal battery or a donor car's cigarette lighter plug, can't really jump-start a car for just the reasons you fear—the wires are too light-gauge to carry the 100 to 200 amps necessary to spin a starter motor. Not to mention these sockets are generally fused to 10 amps. But they can recharge a battery that's just a little too low in 10 minutes or so, hopefully enough to get the dead car started. They won't help much if the dead car

has a thoroughly discharged or bad battery, or with a motor that's just plain hard to start because of some mechanical issue. And, as you say, they won't work unless the key is turned on. These light-duty boxes are fine for a quick and partial charge but won't provide any boost when the key is in the starting position. Actually, that's how they get away with the light-gauge wires—they aren't carrying any current when you're trying to start the dead car. Some vehicles have sockets that are hot full-time, and in those cases a jump box that's left connected when the key is moved to the "Start" position could smoke the wires or blow a fuse if the dead car doesn't light in a few seconds. While I'm not a fan of these small jump boxes, they're not a bad option for those unwilling or unable to manage a set of conventional jumper cables—and you don't need a second car to use them.

Fore!

My 2005 Saturn ION has very small divots in the windshield. It's fairly difficult to feel them, but on a sunny day they'll catch the light and become

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visible. Is there a way to polish them out or add a wax, or is the only solution to replace the windshield?

If they're actual divots caused by sand-blasting, any good glass shop can polish them out. If they're mineral deposits, which will stand proud of the glass, you probably can remove them with vinegar or even rubbing compound.

How Low Can You Go?

Do low-profile tires tend to hydroplane more than regular tires?

All other things being equal, wider tires hydroplane more than narrower tires. Since most low-profile tires are wider, the answer to your question is a qualified yes. But if you had tires of the exact same tread width and pattern, simply different sidewall heights, there wouldn't be much difference.

Venting

I recently had a serious water leak in my vehicle. I first thought it was coming from the heater-a/c unit under the dash. However, the local GM service manager advised me that one sunroof drain line had become disconnected and two others were plugged up with "biological material," causing the leak. I don't know where the drains are located in the sunroof, and then I'd like to know if there's any type of preventive maintenance that I might try.

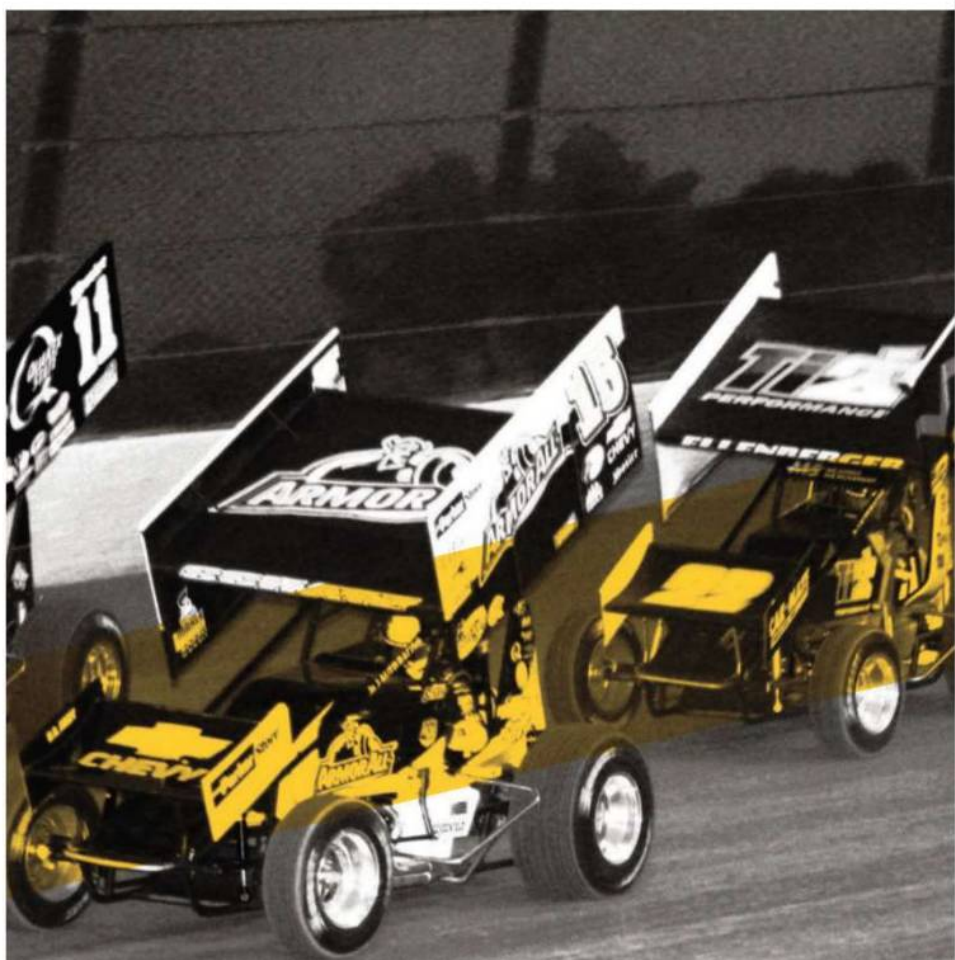
Plugged or discombobulated sunroof drains are fairly common. Usually, if they're plugged, I just blow them out backwards with compressed air. Finding the downstream ends of the tubes is the problem. You'll need to check the service manual—or ask a service technician at the dealer, who probably has seen the same problem a hundred times. Reattaching a loose drain tube is more problematic. Some sunroof designs allow you to actually see the

top end of the tubing where it's attached to the sunroof mechanism. Usually the tubing simply pushes over the nipple on the drain, which is pretty lame. I use safety wire or teeny hose clamps to keep this from happening repeatedly. Other sunroofs must be partially disassembled before you can see and repair the tubing/water-tray attachment. Your late-model vehicle probably has tubing that's still intact—older vehicles sometimes suffer from disintegrated tubing, requiring partial disassembly of the roof liner, A-pillar and

dash to thread in a new tube.

"Biological material"? That's code for slime and mildew, probably growing in the remnants of leaves, pollen buildup and dead insects that tend to collect in the corners of the sunroof mechanism. Clean this area periodically by opening the sunroof and using a soft brush, a vacuum or even Q-tips to remove any foreign matter inside the seal. A generous spray of Lysol or other disinfectant couldn't hurt, either—but don't douse so much on that it wets the headliner, which could stain.

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DSLR Lenses, Demystified

THE CAMERA BODY IS SIMPLE AND STRAIGHTFORWARD. THE LENS IS A DIFFERENT—AND OFTEN CONFUSING—STORY. HERE'S THE LONG AND SHORT OF IT. BY GLENN DERENE

➔ In the quaint old days of analog photography, the single-lens reflex, or SLR, was the tool of choice for professionals and dedicated hobbyists. Digital technology has made digital SLRs, or DSLRs, so affordable and simple to use that droves of amateurs have embraced them as a step up from basic point-and-shoot cameras.

Many consumer-grade DSLRs, such as the Nikon D60 I bought two years ago to photograph my newborn son, are sold as kits with a basic zoom lens. The kit lens is versatile, but many novice users never move beyond it—and who can blame them? The sheer number of options is dizzying (Nikon, Sony, Canon, Pentax and Panasonic all offer dozens of lenses), and DSLR lenses are categorized and sold using an impenetrable argot that would put off any newbie.



← **OPTICAL ENGINEERING**
Modern lenses are super high-tech. A typical 18–55-mm zoom lens has 11 elements, multiple drive motors, optical image stabilization and an integrated circuit board.

It's a shame that the threshold—or, at least, the perceived threshold—is so high, because a principal benefit of DSLRs is the flexibility to swap lenses. Pro photographers treat lenses like golf clubs, carrying around a bagful and pulling out the right one for each shot. I was eager to gain that

kind of expertise and versatility, so I borrowed a bunch of lenses from Nikon and went out shooting with Lester Lefkowitz, an instructor at the International Center of Photography in New York City. The experience taught me what a difference the right lens can make to a photo—it's even more crucial to the

end result than the camera itself.

I also learned that obtaining the right lens requires spending wisely, refining your interests and understanding a few basics.

Focal Length

➔ **Take a close look** at the barrel of a lens and you should see a measurement, or range, such as 18–55 mm. That's your lens's focal length—the

INSIDE

✕

JAILBREAKING IPHONES + LASER BURN-IN + GOOGLE INSTANT

distance from the lens to the sensor. Different sensor sizes can skew the math a bit, but in general longer focal lengths work like telescopes (to focus on objects in the distance), while shorter focal lengths are used for wide-angle photography (to take in as much of a scene as possible). Zoom lenses offer a range of focal lengths.

F-Stops

➔ **Also printed** on the barrel of every lens is the f-stop rating (e.g., f/3.5). F-stops refer to the diameter of the lens aperture, which determines how much light enters the camera. F-stops seem counterintuitive at first—the lower the number, the wider the aperture—until you realize that they are not a direct measurement but denote the ratio between the lens's aperture and its focal length. The number printed on the lens is the lowest possible f-stop, or widest aperture, for that lens. On consumer zoom lenses, the maximum aperture is noted as a range—such as f/3.5–5.6—because, as you zoom, the focal length changes along with the maximum f-stop.

The actual stops typically range from f/22 to f/1.4, with settings such as f/11, f/5.6 and f/2.8 in between. Each incremental stop doubles the area of the aperture.

Once you understand the vocabulary of focal lengths and f-stop ratings, you'll possess the basic know-how needed to explore the various lens categories.

Zooms

➔ **Most DSLR kits** come with a zoom lens—the most versatile club in the bag. My D60 was equipped with an 18–55 mm (similar zooms are available from other manufacturers). At its short-

est focal length, 18 mm, it is a relatively wide-angled lens, good for shooting scenery and groups of people; at its longest, 55 mm, it serves as a portrait lens, allowing you to pull in close to the face of your subject from several feet away. The beauty of a zoom lens is that you can adjust it from wide to telescopic with the turn of a dial.

Zoom lenses come in a variety of configurations that overlap considerably with other lens categories. Wide-angle zooms can cover focal lengths from 10 mm to 24 mm. Telephoto zooms can cover 55 mm to 200 mm, or 200 mm to 400 mm. You can even get a super-flexible zoom lens that ranges focal lengths from 28 mm to

LENS LESSONS

The author went into the field with Lester Lefkowitz, a photographer and instructor at the International Center of Photography, to learn a few lens basics.

TELEPHOTO



Telephoto lenses bring the action closer, but can also compress the apparent distance between objects. "Notice how the lifeguard and island look closer together in shots two and three, which were taken at greater focal lengths than the first photo was," Lefkowitz says.



Lens: 18–55-mm zoom; focal length 55 mm



Lens: 55–200-mm zoom; focal length 200 mm



Lens: 300 mm, a single-focal-length lens

MACRO



At a farmers' market, we first shot these raspberries with the highest magnification possible on the 18–55-mm zoom lens that came with my Nikon D60 kit. Then we took the same shot at two magnifications with a 105-mm macro lens. The last shot is a 1:1 magnification of the fruit.



Lens: 18–55-mm kit lens; closest focus



Lens: 105-mm macro; 1:2.5 magnification



Lens: 105-mm macro; 1:1 magnification

300 mm. Sounds great, right? One lens that does everything—why doesn't everyone just get one of those and be done with it? The answer is that flexibility generally comes with added complexity, weight and cost. A Canon EF 28–300-mm lens, for instance, has 22 lens elements, weighs 3.7 pounds and costs \$2400, enough to break the budget of most non-pro photographers.

Prime Lenses

➔ **My favorite type of lens**, the prime, is the converse of a zoom. A prime lens has a fixed focal length and is optimized for a certain type of photography. Available from 10.5 mm all the way up to

600 mm, primes are simpler in construction and generally lighter than zooms. Plus, they take better photos.

Consider this comparison: At its maximal focal length, Nikon's 18–55-mm kit lens is rated at f/5.6. A NIKKOR 50-mm prime lens (\$485), on the other hand, is shorter and uses bigger glass, so it is rated at f/1.4. The lower f-rating means more light and greater control over depth of field, yielding crisper, more powerful portraits.

Wide-Angle and Telephoto

➔ **The lower the focal length**, the wider the field of view—anything under 35 mm is typically considered wide-

angle. These lenses are useful for photographing interiors, where you can back up only so much before hitting a wall. But super-wide-angle lenses can cause distortion toward the edges of photos. A well-designed (and, generally, expensive) lens can fight such distortion.

Some extreme wide-angle lenses, called fisheye lenses, don't fight distortion at all. Rather, they take advantage of it. The effect can be pretty dramatic, even a bit trippy. Fisheye lenses can be useful for taking in the huge crowd at a stadium—or getting right up in someone's face for a warped portrait.

Telephoto lenses, on the other hand, act like telescopes, as the name suggests. (I've taken to using a 200-mm lens to sneak up on a cardinal in my backyard.) When you magnify a distant object, however, you also amplify any movement of the camera itself, so image stabilization technology or a tripod is a must.

Macro

➔ **If a telephoto lens** is like a telescope, a macro lens is like a microscope, useful for taking closeup shots of flowers, insects and other little wonders of the natural world. A macro lens's best quality is its ability to maintain sharpness at high magnifications. High-quality macro lenses can achieve 1:1 reproduction, meaning the subject matter can be captured by the camera's sensor at life size.

Lenses can become an expensive habit. Off-brand models may save you cash, but my experience so far has shown that with optics you generally get what you pay for. After my brief lens tutelage with Lefkowitz, I was inclined to buy up all the test lenses loaned to me rather than return them. But sanity prevailed, and I settled on one, a very fine 50-mm prime lens. My photos of my son have never been so good.

PM

LESTER LEFKOWITZ

DEPTH OF FIELD

↓
By adjusting the lens aperture, you control the depth of field. "A wide-open aperture, or low f-stop number, will create a shallow depth of field and make the subject pop, like the fern below," says Lefkowitz. "A higher f-stop number [bottom] can put more of the world in focus."



Lens: 70 mm; aperture f/2.8, wide open



Lens: 70 mm; aperture f/22, closed down

WIDE-ANGLE

↓
Many consumer DSLRs are sold as a kit with an 18–55-mm zoom lens. "The photo below is shot with a kit lens at its widest, 18-mm setting," says Lefkowitz. "Shooting from the same spot with a lens that zooms to 10 mm [bottom], we're able to capture much more of the fountain."



Lens: 18–55-mm zoom; setting 18 mm



Lens: 10–20-mm wide-angle zoom; setting 10 mm

China

(CONTINUED FROM PAGE 85)

August 9, 2015

1215 hours

THE BATTLE TO DEFEND THE *Nimitz* no longer begins with missiles, but with robots. Hours before the carrier group reaches those lurking diesel-electric Kilos, the carrier's escort ships deploy a handful of unmanned underwater vehicles (UUVs) to patrol between Taiwan and Okinawa.

These torpedo-size drones use continuous active sonar (CAS) arrays, which release a steady stream of energy, the sonar equivalent of a spotlight. "CAS will change the calculus from the sub being the hunter, to being the hunted," says Waickwitz, who now works for Virginia-based Alion Science and Technology, which is testing its CAS technology on a surface vessel and next year plans to begin testing the sonar on UUVs.

The robots protecting the carrier group aren't armed, but the nuclear-powered Virginia-class sub monitoring their progress certainly is. The Chinese subs lying in ambush must scatter before firing or be sunk.

There are ways to make air defenses more resilient as well. This time Kadena is better prepared for hacker attacks, thanks to sophisticated missile defense batteries like the Medium Extended Air Defense System. Instead of relying on a single computer network to coordinate anti-air launches, each MEADS can operate autonomously and cover 360 degrees of sky.

With the Air Force base functional, F-15s (and, later, F-22s flying in from Hawaii) can guard the *Nimitz*, engage the incoming decoys and preserve the group's supply of anti-air missiles.

The Chinese fighters launch their missiles, but only two reach the *Nimitz*. Pilots and sailors are killed and wounded, but the flight deck is intact, and the carrier's mission to protect Taiwan can continue.

There's one more threat to counter, though. The ASBMs take off from

five different locations in southeastern China. One of them is spotted by an American stealth UAV, one of a handful operating high-endurance missions out of Kadena. In 2009 the U.S. Air Force confirmed the use of the first radar-deflecting drone—the RQ-170 Sentinel—on surveillance missions over Afghanistan.

By 2015 the Air Force is flying heirs to the Sentinel that are armed with experimental Network-Centric Airborne Defense Element missile interceptors. Fired from standard air-to-air launchers, these missiles can strike ballistic missiles before they leave the atmosphere. When tensions between China and Taiwan began to rise, the Air Force quietly rushed the experimental weapons from the Nevada Test and Training Range to Kadena.

The high-endurance UAVs can loiter, unseen, waiting for a ballistic missile launch. When their sensors detect the rocket's plume, two of the UAVs fire at the rising missiles, and one scores a hit; the missile disintegrates into a ball of burning fuel and debris. That's one fewer carrier-hunting missile streaking at the *Nimitz*.

Another is knocked out in space by SM-3 interceptors. Now three are entering the ASBM's signature death dive. The Aegis ships shoot again, but during this replay they are using a new model, the SM-2 Block IV. Like most terminal-phase systems, it is a defensive Hail Mary. Two ASBMs miss, but a third is clipped by an SM-2 and dumps into the sea.

The hot wash ends with the carrier safe, its presence thwarting the invasion and tipping the scales toward Taiwan during cease-fire negotiations.

Preparedness is the cornerstone of deterrence, and some analysts say that the Pentagon must match Chinese advances to prevent conflict. "Part of what keeps the probability of war so small is that the U.S. and Taiwan have taken steps to make sure it would be painful for China," RAND's Shlapak says.

As it adapts to China's strengths, the Pentagon is confronted with an unfamiliar position. The battle for Taiwan—even if no shots are ever fired—has already begun. **PM**

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Tonight There's Gonna Be a Jailbreak

I read that a recent ruling made it legal to "jailbreak" an iPhone. What's this mean? Should I do it to mine?

A You can, but it's risky. First, some background: Jailbreaking basically means manipulating the firmware on an iPhone, iPad or iPod Touch so that it can run programs that—for one reason or another—weren't cleared through Apple's official App Store. (It's not to be confused with "unlocking," which is the process of, for example, hacking an AT&T-only phone to run on T-Mobile.) Despite a number of security risks, enterprising users have been jail-

breaking their phones pretty much as long as these devices have been around. In fact, incremental updates to Apple's iOS mobile operating system have begun to feel like a cat-and-mouse game: Apple releases a new version of its OS, and hackers find a way to crack it open—often within hours.

Until recently, jailbreaking lived in that murky gray area where so much of digital copyright law resides. (Technology tends to move a lot faster than leg-

islation.) While it seems to be a violation of the Digital Millennium Copyright Act (DMCA), which forbids people from hacking copy-protection software, not a single person has been prosecuted for it. Any doubts as to the legality of jailbreaking were laid to rest in July when the Library of Congress, which is charged with reviewing and issuing specific exceptions to digital copyright law every three years, ruled that the process is definitely legal.

So why would you want to jailbreak your device? First, because you can, and it's incredibly easy. Beyond that, Apple is famously strict about what sort of programs it allows in its App Store. By jailbreaking your iOS device, you can load it with programs that

didn't get past the App Store gatekeepers. Jailbreaking also allows you much more freedom to manipulate backgrounds, fonts and the general feel of your gadget.

And while jailbreaking used to involve a drawn-out process of downloading and syncing various files, new methods allow it to be done in seconds without even plugging in the device.

First step: Back up your iPhone, iPad or iPod Touch in iTunes—that way, if anything goes wrong, you can easily recover all of your files and contacts. Then open the device's browser and direct it to jailbreakme.com. You'll be greeted with a bar labeled "slide to jailbreak." Slide the bar, wait for the process to finish, and reboot your device. Congratulations! Your Apple device is now jailbroken.

When your device reboots, you'll see an app called Cydia on the home screen. Cydia is a sort of renegade app store—a hub for downloading all sorts of programs that didn't make it into the official App Store (I'm a particular fan of ones that allow you to sync your device over Wi-Fi and turn off its accelerometer)—and a great place to get started exploring the possibilities of a jailbroken device. (It should be noted that Apple had effectively blocked this browser-based method of jailbreaking as of press time, but we fully expect hackers to get it working again—perhaps by the time this issue hits newsstands. Either way, a quick Google search should reveal alternative methods for jailbreaking your device.)

However, jailbreaking isn't for everybody. First of all, while it may be legal, Apple insists it violates the warranty. And while the process lets you experiment with unauthorized programs, it also exposes you to a certain amount of risk. Apple has done a very good job of keeping viruses, malware and other types of programs that could potentially damage your device out of its App Store. Jailbreak your gadget and you leave the relative safety of this protective bubble. A number of cyber-security experts have warned that jailbreaking a device could leave it vulnerable to viruses and hackers. We've also heard reports of some jailbroken devices generally acting slow and buggy. So,

potential jailbreakers, proceed at your own risk.

Instant Gratification

I love the new Google Instant feature.

Am I missing anything by using it instead of doing a full-fledged search?

You may be. Google Instant is one of those new features that feels like magic. As you type your query, the search engine tries to predict what you are searching for and automatically updates the results as you type—without you ever hitting the Enter key or Search button. The closer you get to finishing your query, the closer Google gets to perfectly predicting it.

There's at least one caveat, however. Google's prediction algorithm relies heavily on how popular certain sites and searches are. And if there's one thing the Internet has taught us, it's that the most popular sites and searches are rarely the most family-friendly. So it should come as no surprise that, rather than subject all users to potentially not-safe-for-work results, Google Instant filters out some of the bluer content. Of course, like any automatic Internet filter, Google Instant also incidentally blocks some less offensive results (subjects in the arts and health arenas come to mind) that happen to share keywords with more prurient interests. Want to see all of the results? Click "Search" like you used to.

Laser Burn

I was at a big concert festival with a massive laser light show, and I got to thinking: Can a laser's bright light damage my camera?

It sure can. Like your eyes, a camera sensor is highly sensitive to light—it has

to be in order to compile a photograph from an exposure that lasts just a fraction of a second—and it quite simply isn't designed to handle a laser's extraordinarily concentrated beam. "A laser could be powerful enough that a single hit could permanently damage the sensor—I've actually had this happen to me a number of times," says Patrick Murphy, executive director of the International Laser Display Association. The damage can range from a few dead pixels to a camera-ruining laser burn-in. In fact, Flickr and YouTube have some pretty amazing videos and photos produced by laser-burned cameras. In some of them, you can actually see the laser swipe across the screen, leaving a trail of dead pixels in its wake. Of course, in order for this to occur, the beam has to shine directly into the lens at just the right angle to hit the sensor, so shooting a room full of crisscrossing lasers is still fine.

So does this mean you should leave your camera at home the next time you go to a concert? Probably not. According to Murphy, it is illegal for laser shows to shine their beams directly into an audience. In the U.S., lasers must be kept at least 3 meters from anywhere the audience can physically reach. Of course, underground raves and rule-bending laserists are another story. **PM**

Got a technology problem?

Ask **Seth** about it. Send your questions to pmdigitalclinic@hearst.com or over Twitter at twitter.com/sethporges. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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This Is My Job

× MOUNTAIN GUIDE

Name: JOHN RACE
Location: LEAVENWORTH, WASH.
Age: 41
Years on Job: 22

× After he graduated from college, John Race considered law school—but an expedition to the Himalayas' Shishapangma Mountain changed the course of his career. Since then, the alpine guide has led trips up Denali and Everest and retraced explorer Ernest Shackleton's route across South Georgia Island on skis. Race plans all the trips he guides and provides medical care en route. He advises novice climbers to take it one day at a time. "The biggest goals are too big to digest at once," he says. "Those who stand on top aren't always the most talented, but they're the most dogged." — EMILY HAILE

1. AVALANCHE BEACON

This 13.6-ounce Tracker DTS avalanche beacon pulses at 457 kHz, the standard international frequency. If a climber gets buried, group members switch their own beacons to receive the signal and begin searching. The first 15 minutes are crucial for survival. After that, "things get pretty grim," Race says.

2. ICE TOOL

The Petzl Nomic Leashless Ice Climbing Tool has a steel pick and an aluminum-alloy shaft. "You could stick it in a crack and stand on it, and you're not gonna break it," Race says. Strong and versatile, it allows for dry-tooling—navigating dry, rocky patches—as well as vertical climbing on ice.

3. OXIMETER

Race carries a Nonin Medical oximeter—which measures blood-oxygen saturation and pulse rate—on all high-altitude expeditions. The device operates in temperatures down to minus 22 F. When a team member's oxygen levels drop, Race may mandate a retreat to lower altitudes.

4. SKIS

Race owns six pairs of skis for snow conditions from deep powder to breakable crust, but the G3 Spitfires are the best all-purpose skis in his collection. They perform well on downhills and, at 7.7 pounds per pair, are light enough to make ascents comfortable. "It's not an outrageously sexy ski," he says, "but it's super-reliable."



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